PLANT PATHOLOGY

A RECORD OF CURRENT WORK ON
PLANT DISEASES AND PESTS

Published quarterly for the
Ministry of Agriculture, Fisheries and Food
Plant Pathology Laboratory
Harpenden, Herts

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CABBAGE STEM FLEA BEETLE IN EAST ANGLIA

by J. J. W. WILLIAMS* *and* P. W. CARDEN
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CABBAGE stem flea beetle, *Psylliodes chrysocephala* L., attacks a wide range of overwintering brassica crops in certain years (Newton 1929, Roebuck 1936). After severe attacks in East Anglia during the winter of 1949-50 it was decided to study its biology with the object of finding suitable control measures.

I. BIOLOGY AND PRELIMINARY TRIALS ON CONTROL †

Knowledge of the life history of the pest in this country was limited and the only published work by Newton (1929) did not elucidate the number of generations each year. Records from 1942 for East Anglia showed that damage was severe and widespread for two or three seasons followed by a few years of little or no damage. Little damage occurred during the winters of 1950-52, when the writer started work on the problem at the N.A.A.S. regional centre at Cambridge.

DAMAGE

Plants affected were mainly overwintering brassica seed crops. Larvae damaged the plants by tunnelling through stems, petioles and shoots (Plate III, 1). The damage first appeared as small holes on the stems and upper surfaces of petioles and later tunnels could be seen under the epidermis. More holes appeared where the tunnels broke through the epidermis and Godan (1951) attributes these holes to the increasing oxygen needs of the moulting larvae. Later on, leaves turned yellow and fell from the plant. Larvae were rarely found in these fallen leaves and cage experiments showed that larvae left them and attacked healthy plants. Severe mining of the stem led to the epidermis peeling off and death of the plant often followed such damage. Bacterial soft rot was often associated with larval damage, particularly in swedes and turnips, and many plants, which would have recovered from larval damage alone, died of soft rot. Damage was first observed in the third week of August, 1949, and the first week of September, 1950 and 1951. Obvious mining with yellowing and defoliation did not occur until early October and continued through the autumn and winter, usually ending by late February. The pattern of damage was similar for each year studied. The numbers of larvae causing plant mortality varied widely with crop growth stage and seasonal conditions. In February, 1951, a crop of swedes at Feering in Essex, with an average of ten larvae per plant, appeared unaffected. This was one of the few crops of infested swedes in which no soft rot was found. In November, 1950, a crop of swedes with up to 80 larvae per plant was a complete failure, and without exception each plant of a hundred examined had soft rot.

LIFE HISTORY

Observations on the life history were made on a field at Burwell Fen, Cambridge, in which rape grown for two consecutive seasons was severely attacked, and these observations were augmented with information from various brassica crops in other parts of East Anglia. Live material was also kept in cages to help interpret what was happening in the field. Adults started emerging in the cages on May 22, 1950, and 80 per cent had appeared by May 23; no

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more emerged after May 27. In the field sweeping was started in mid-May. The first adults were caught on June 2 at Burwell and numbers increased to a peak, averaging 48 per 20 sweeps, by June 22. Numbers decreased after mid-July to an average of 2 per 20 sweeps by the end of the month. Emergence on the Burwell field began on June 10, 1951, and June 4, 1952.

There was an aestivation period towards the end of July when beetles kept in cages stopped feeding and sheltered in crevices and under leaves; at the same time numbers of adults caught by sweeping at Burwell and other sites began to decrease and adults were found in hollow stems and under plant debris on the ground. During August beetles reappeared on the plants and fed on the leaves. Only once were adults found in sufficient numbers to cause serious damage by feeding on a crop and this was on summer cabbage in the Spalding area of Lincolnshire in August, 1950. Kaufmann (1941) in Germany referred to a long aestivation period in mid-summer and attributed it to low humidity.

Beetles bred in cages and those caught in the field were dissected each week and the ovarioles and fat bodies examined. Newly emerged beetles had large fat bodies and small immature ovarioles. By early August, well-developed eggs were present in the ovarioles, and oviposition began during the third week of August in cages and the fourth week in the Burwell field, eggs being found in the soil at the bases of plants. Beetles kept in 4 × 1 in. glass tubes laid eggs on glass, cotton gauze and in cracks in the cork. Adults became increasingly difficult to find on plants during the winter months but could be found under fallen leaves and in sheltered places. By early spring it was difficult to find any adults.

First stage larvae were found in plants at Burwell Fen on September 7, 1950, and about this time in 1951 and 1952. By the end of October all three larval stages were present in attacked plants and it was at this time of the year that growers usually noticed damage. Plant samples taken from a trial field at Feering show the fall in larval numbers during February to April (Table 1). The first count was made on February 7 and it is possible numbers had already started to fall by this date.

TABLE 1

Larval Counts on Swede Field at Feering, Essex, 1951

	Feb. 7	Feb. 19	Mar. 11	Mar. 25	April 9	April 23
Numbers of larvae per 50 plants	489	451	403	253	149	42
Percentage of larvae found in plants	100	92	82	52	30	9

Larvae bred in cages started leaving the plants during the second week of February. They burrowed to a depth of ½ to 1 in. in the soil and were found curled up in small earthen cells. Pupae were formed in 3-4 weeks and the adults emerged 8-12 weeks after pupation.

It was concluded from these observations over three years that there was only one generation a year in Eastern England. Adults emerged in June and after a period of feeding followed by aestivation, commenced egg laying in late August or early September and continued throughout the autumn and

occasionally into spring. The small proportion of adults which survived the winter and laid eggs during the spring could be mistaken for newly emerged adults, giving an impression of two generations a year.

CULTURAL CONTROL

It was noticed that crops sown before mid-July or later than August suffered less severe damage than those sown during the intervening period. Unfortunately early sown crops may be too forward to withstand severe winter conditions and late sown ones may not yield well. Late July or August is the optimum sowing date for successful overwintering but such crops are most susceptible to cabbage stem flea beetle. Kaufmann (1941) noted that early sown crops, although first attacked, were not as badly affected as those sown at intermediate dates, and the last sown suffered little damage. Bonnemaison and Jourdheuil (1954) also drew attention to the effect of sowing date on damage.

Kaufmann (1941) suggests that successive years' crops should be grown as far apart as possible to reduce the number of adults moving from the old to the new crops. Observations in Eastern England have shown that serious infestations of this pest can nearly always be traced to a build-up on neighbouring fields over several years.

CHEMICAL CONTROL

At the time this work was done there was no information on chemical control. Subsequently Veenenbas (1953) recommended two to three applications of DDT at 2-3 weeks intervals from September onwards against the adults, and he also recommended parathion to control larvae in the mines. Bonnemaison and Jourdheuil (1954) used aldrin, dieldrin and lindane successfully against the adults and parathion and lindane against the larvae.

Trials were started in the autumn of 1950 with the object of killing adults before they had laid many eggs. In view of the mobility of the beetles, large plots were thought essential. One half of the crop on five fields was treated and the remainder left as a control. DDT emulsion (0·1 per cent at 100 gal per acre) was applied with a knapsack sprayer and a 5 per cent DDT dust at 56 lb per acre with a rotary duster. Table 2 gives details and results of the trials.

The DDT dusts and sprays gave an appreciable reduction in the numbers of attacked plants and of larvae. At Goldhanger plants were infested before treatment and there was a reduction in larval numbers but not in percentage of damaged plants.

Although infestations in 1951 were generally very low, a uniform attack of about 10 larvae per plant was found on a field of swedes grown for seed at Orford, Suffolk, in January, 1952. A trial was made to try and kill the larvae in the mines. Unreplicated plots eleven yards square were sprayed with different strengths of *gamma*-BHC on February 7 and fifty plants per plot were examined on February 19 and again on March 11. The plants were cut open and the numbers of larvae killed or affected were recorded. Table 3 gives details of treatments and results.

Up to 3-4 weeks after spraying, many larvae from the plots treated with *gamma*-BHC were found to be moribund, showing definite signs of life but unable to feed or make normal co-ordinated movements. Some of these larvae also had a pronounced and abnormally yellow swelling extending over several abdominal segments. Successive counts showed that these larvae had died and only very few live larvae were left, possibly in leaves which had missed being sprayed. (Tables 3 and 4).

TABLE 2
Results of Field Trials 1950

Site	Crop	Treatment	One month after last treatment	
			Plants with live larvae *per cent*	Mean No. of larvae per plant
Feering, Essex ...	Swedes	Sprayed DDT Sept. 2 and 23	4	1
		Untreated	27	1·9
Stanway, Essex	Spring Cabbage	Sprayed DDT Sept. 12	5	1
		Untreated	20	2
Stanway, Essex	Swedes	Sprayed DDT Sept. 12 and Oct. 3	20	1·0
		Untreated	64	1·8
Goldhanger, Essex	Swedes	Dust DDT Sept. 25 and Oct. 16	40	1·6
		Untreated	40	2·6
Holbeach, Lincs.	Swedes (Seedbed)	Dust Sept. 18 and Sept. 28	9	1·0
		Untreated	63	2·0

It was often difficult to distinguish between larvae killed by the treatment and exuviae, so to prevent bias between the treated and untreated plots all exuviae were recorded as "dead larvae." It is probable that this accounts for the majority of "dead larvae" on the untreated plots. Comparison of the total larvae found per treatment showed that in some cases many dead larvae were being missed in the dissection. Because of these difficulties with moribund larvae, dead larvae, and exuviae, the most reliable measure of treatment effect is given by the number of larvae active at least four weeks after treatment in a set number of plants.

In view of the difficulty of timing applications for adults and of forecasting their occurrence, the success of *gamma*-BHC suggested that control of the larvae after an attack had developed was the most profitable line of investigation.

TABLE 3
Results of Trial at Orford, Suffolk, 1952

Gamma-BHC per acre	No. of larvae per 50 plants February 19, 1951				No. of larvae per 50 plants March 11, 1951			
	Normal	Moribund	Dead		Normal	Moribund	Dead	
			No.	*per cent*			*No.*	*per cent*
20 gal 1·2 *per cent*	5	283	84	13	0	1	306	100
20 gal 0·6 *per cent*	32	314	64	16	3	9	308	96
100 gal 0·2 *per cent*	0	218	91	30	0	1	304	100
100 gal 0·1 *per cent*	7	381	36	9	0	5	269	98
100 gal 0·05 *per cent*	3	359	81	19	0	6	279	98
Untreated	451	0	2	0·05	403	7	16	4

II. FURTHER TRIALS ON CONTROL AND ON THE EFFECT ON YIELD †

Treatments effective against the larvae can be applied after an attack has started to develop rather than as a precautionary measure so this method of control has been developed and observations made on timing and on the effect of treatment on yield.

A preliminary trial was made in 1952-53 on turnips at Bawdsey, Suffolk. In subsequent years most of the serious attacks recorded were on coleseed (winter rape: *Brassica napus*, var. *oleifera*, subvar. *biennis*) in the Isle of Ely, so the later trials were on coleseed on farms near March.

Randomised block designs were used for comparison of materials, rates and times of application. For observations on the effect of treatment on yield pairs of plots, one treated and one untreated, were marked out in different parts of suitable fields. The sprays were all made up from miscible liquids and applied with a knapsack sprayer.

The degree of attack was assessed by counting the number of larval mines in 20 plants taken from the diagonals of the central part of each plot. No plants were taken from the outside rows or from a 1 yd strip at each end of the plots. The accuracy of this count as a measure of the actual larval population was checked on samples of 20 plants pulled in December from three control plots in one trial. It was found that the number of larvae was being slightly over-estimated but the number of mines counted was giving a good estimate of the relative larval populations (there were 83 to 85 larvae per 100 mines).

As the season progressed the mines became more extensive and difficult to separate and the estimates probably less precise. Treatment effects were measured by later counts of mines and by dissecting the larvae out of a few plants per plot, the number depending on the larval population. These counts were made at least four weeks after treatment to give the moribund larvae time to die.

COMPARISON OF MATERIALS AND RATES OF APPLICATION

In 1952-53 several rates of *gamma*-BHC (Table 4) were compared in a trial of five randomised blocks with plots $5\frac{1}{2}$ yd square. The trial was laid out on turnips 12-18 in. high when the treatments were applied on December 10, 1952. All larvae were dissected from samples of 10 plants per plot pulled on January 5, 1953, 26 days after treatment. A second sample of four plants per plot was dissected on February 3 (55 days after treatment) to confirm the fate of the moribund larvae present at the time of the first sampling.

All treatments gave excellent control of the larvae. The crop was ploughed in during the winter because there was no market for the turnips, but by that time the untreated plants had suffered much more damage from cabbage stem flea beetle than the treated plants.

Excellent control was again given by 0·1 per cent *gamma*-BHC at 100 gal per acre on a plot of coleseed sprayed on October 20, 1953. The level of attack was uniform on the treated and untreated plots before spraying, but on November 17 there were 21 living larvae per plant on the untreated plot and none on the treated plot. On December 21 there were 34 larval mines per plant on the untreated plot against 6 on the treated plot. This crop was also ploughed in after severe weather in January and February. The farmer

† by P. W. Carden.

attributed the failure of the crop to frost damage, but much of the damage was in fact caused by cabbage stem flea beetle, and in the absence of the pest the crop would probably have survived.

TABLE 4

Condition of Larvae 26 and 55 Days after Treatment with Gamma-BHC

Gamma-BHC per acre	No. of larvae per plant on January 5, 1953				No. of larvae per plant on February 3, 1953		
	Active	Moribund	Dead	Moribund or dead *per cent*	Active	Moribund	Dead
40 gal 1·0 *per cent*	0·2	3·5	9·0	99	–	0·1	12·2
56 gal 0·1 *per cent*	2·1	4·8	8·5	87	0·2	0·45	13·6
224 gal 0·1 *per cent*	0·3	3·5	10·5	98	–	0·1	11·8
240 gal 0·05 *per cent*	1·2	4·9	10·3	93	0·1	–	13·6
Untreated	14·0	0·1	0·9	7	13·2	0·2	2·0

In 1954-55 several lower rates of *gamma*-BHC were compared with dieldrin and parathion (Table 5) in a trial of three randomised blocks of plots 5½ yd square. The cabbage stem flea beetle attack was comparatively light: 3·9 larval mines per plant on October 28. In addition to the counts of larval mines made on the trial, more frequent counts were made on plants along a transect across the field to show the general progress of the infestation:

	Oct. 15	Oct. 20	Nov. 4	Nov. 17	Nov. 25	Dec. 15	Jan. 28
Larval mines per plant	0	0·6	3·2	6·7	6·3	5·9	4·9

The plots were sprayed on November 4. All larvae were dissected out of 10 plants per plot pulled on November 29, and counts of larval mines per 20 plants were made on January 25, 1955. The number of living larvae per plant again gave the best measure of treatment effect, but the number and percentage of dead larvae are given to show that the differences were not solely due to uneven infestation of the plots.

TABLE 5

Comparison of Materials and Rates of Application, 1954-55
(Means of three Plots)

Treatment per acre	No. of larvae per plant on November 29			Larval mines per plant on January 28
	Alive	Dead	Dead *per cent*	
	±0·37			±0·46
100 gal 0·05 *per cent gamma*-BHC	0·1	2·4	97	0·5
100 gal 0·01 *per cent* „	1·5	1·6	48	3·0
20 gal 0·1 *per cent* „	0·7	1·7	72	1·4
20 gal 0·05 *per cent* „	0·4	1·3	78	1·6
2 pt. 15 *per cent* dieldrin in 20 gal	0·5	1·6	75	2·3
8 fl. oz. 20 *per cent* parathion in 100 gal	0·0	1·8	100	0·8
Untreated	2·9	0·7	19	4·0

The best control was given by 0·05 per cent *gamma*-BHC at high volume, and parathion, followed by both low volume rates of *gamma*-BHC and dieldrin. High volume 0·01 per cent *gamma*-BHC was not satisfactory. The number of larval mines per plant in January suggested that dieldrin was not as good as the other treatments. Although parathion gave excellent control it was not used in later trials because of its high mammalian toxicity.

Another trial of similar design showed the period during which treatment was effective. Sets of plots were sprayed with 0.05 per cent *gamma*-BHC at 100 gal per acre on October 8, October 28, and November 17. Counts of larval mines were made on November 11, December 15, and January 28 (Fig. 1). Each application either prevented a build-up or reduced the number of larval mines per plant on January 28 to 1·1 or less, compared to 3·7 on the controls.

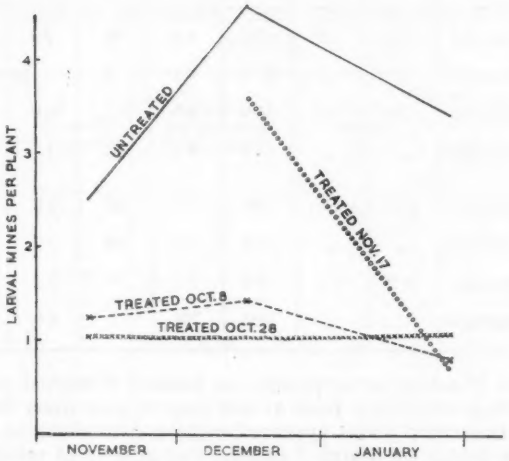

Fig. 1. **Effect of treatment with *gamma*-BHC on different dates in 1954 on damage by cabbage stem flea beetle.**

EFFECT OF TREATMENT ON YIELD

In the autumn of 1956 part of a crop suffering from a heavy attack of cabbage stem flea beetle was also very backward because of poor seedbed conditions. To find the effect of the attack on coleseed at different stages of growth, pairs of plots 5½ yd square, with a 1 yd gap between the plots in each pair, were marked out and one of each pair sprayed (Plate III, 2). The sites of the four pairs were: near the centre of the backward patch; at different points on the edge of the backward patch; and in a stronger part of the crop.

Most of the plants were severely damaged when 20 plants per site were measured and the larval mines on them counted; an application of 0·05 per cent *gamma*-BHC at 100 gal per acre was made on November 29. The size of the plants was recorded as the distance from soil level to the tip of the longest leaf. On January 9, 1957, a sample of 20 plants per plot was measured and all larvae dissected out of three of the plants. Plant counts were made on five 1 yd lengths of row per plot on three of the sites on March 1. To facilitate harvesting all plants were removed from a 2 ft strip round each plot during the spring. The plots were cut by hand on July 5 and threshed on

July 12 by treading out the seed on a tarpaulin; the seed was collected, hand-sieved in the laboratory and air-dried. Dry, total and 1,000 grain weights were then taken, and samples were valued by a seed merchant (Table 6).

TABLE 6

The Effect of Treatment on Coleseed under Different Growth Conditions, 1956–57

Growth conditions		Larval mines per plant Nov. 29	Plant height *in.*	Active larvae per plant Jan. 9	Plant height *in.*	Plants per 5 yd row Mar. 1	Yield per acre *cwt*	Value per cwt *s.*	Weight per 1,000 seeds *g.*
Centre of backward patch	Sprayed	10·4	2·9	0·0	4·4	40	3·8	47·5	3·19
	Unsprayed	,,	,,	45·0	4·1	2	(ploughed in)		
Two places on edge of backward patch	Sprayed	12·0	3·0	1·0	4·7	82	10·0	48·0	3·45
	Unsprayed	,,	,,	26·0	4·2	12	1·2	44·0	2·63
	Sprayed	13·7	4·3	0·0	5·7	92	10·0	50·0	3·36
	Unsprayed	,,	,,	31·0	5·1	45	3·2	47·5	3·15
In a forward part of the crop	Sprayed	10·9	6·2	0·0	7·2	?	7·2	50·0	3·40
	Unsprayed	,,	,,	20·0	7·0	?	4·9	50·0	3·25

The number of active larvae present on January 9 showed that the treatment had given good control. Even at that time of year when there was very little growth the treated plants appeared to have overtaken the untreated in size. The plant counts on March 1 showed that in spite of severe damage to many plants at the time of spraying, the treatment had still greatly increased the numbers surviving the winter. When the plants started shooting in the spring the treated plots on the three worst sites stood out clearly from the surrounding area of stunted coleseed or weeds (Plate III, 2), and even on the best site there was a distinct improvement in the appearance of the crop on the treated plot.

Each treated plot gave more seed than its untreated pair and on the edges of the backward patch the seed was also of better size and ripeness. The treated plots appeared to have ripened about two days earlier than the untreated plots. The reason for the relatively low yield from the treated plot in the forward area is not clear, unless that plot was riper than the others when cut and as a result more seed was lost by shedding. However, yield figures from individual plots of this size are likely to vary considerably and in general the relationship between the yields of these plots is quite consistent with the effect of the treatment on the larvae and with the strength of the plants in the autumn.

To confirm these results and to find the effect of attacks of cabbage stem flea beetle on stronger crops, similar plots were laid down in the autumn of 1957 on a strong crop at Waldersea which was heavily attacked, a fairly strong crop at West Fen, March, with only a light attack and a fairly strong but uneven crop (due to variable fertility) with a very heavy attack at Coldham.

This last crop was already severely damaged when it was sprayed. The plots were sited 30-40 yd from the headland in various parts of the fields in order to get a range of levels of infestation. The size of the plants and the level of attack were determined as in the previous year. The treated plots received about the same quantity of *gamma*-BHC per plot as in 1956 (equivalent to 6 oz active ingredient per acre), but the volume of water was reduced to 20 gal per acre as low volume application is usually more practicable for the farmer. The plots were cut by hand in mid-July. About a fortnight later those at Waldersea and Coldham were threshed in a combine-harvester and those at West Fen by treading out on a tarpaulin. The seed was air-dried, winnowed, and weighed. The samples were again valued by a seed merchant (Table 7).

TABLE 7

Effect of Treatment on Coleseed under Different Growth Conditions, 1957–58

Crop and date sprayed	Growth Index*	Larval Mines per plant on November 7	Plant height *in.*	Increase from treatment	
				Yield *cwt/a*	Value *s./cwt*
Waldersea	1	6·7	22	–†	–
Giant rape	2	14·6	21	3·8	3·0
Nov. 7	3	11·8	18	1·1	0·5
	Mean			2·5	1·2
West Fen	1	1·9	16	1·8	1·5
Dwarf rape	2	4·0	14	2·5	1·5
Nov. 7	3	7·1	11	3·0	–1·0
	Mean			2·4	0·7
Coldham	1	24·0	17	2·0	0·5
Dwarf rape	2	27·3	16	–1·8	0·5
Dec. 12	3	31·7	13	9·0	–
	4	34·5	13	7·9	–
	Mean			4·3	–

* 1 = best part of field; 4 = worst part

† Seed lost from treated plot during harvesting

Dissection of larvae from plants pulled about one month after spraying showed that although there had been a 90 per cent reduction in the number of larvae on all fields, there were more survivors per plant on the fields at Waldersea and Coldham than in previous trials. This may have been due to parts of the plants not receiving any spray because the crops were too tall and dense. Therefore it is considered advisable not to reduce the volume of spray on dense crops to less than 30 gal per acre.

Differences in appearance between treated and untreated plots were only seen at Coldham and these were not as marked as in the previous year. In the three crops the treated plots out-yielded the untreated at eight out of eight sites. There was a slight improvement in the quality of the seed from the treated plots on two of the fields.

Comparison of the yield of seed from the 1956-57 and 1957-58 plots with the attack shows that the number of larval mines per plant at the date of spraying and the resulting yields from the untreated plots are related, but there is a

good deal of variation due to differences in crop growth at the time of the attack and different times of examination; the effect on yield of a given level of attack was less on a strong crop than on a backward crop. If attack is expressed as the number of larval mines per inch of plant height (soil level to tip of longest leaf; mean of 20 plants from the untreated plots) there is strong inverse correlation between the attack and yield on the untreated plots ($r=-0{\cdot}91$ with 12 d.f.). This relationship is much closer than that between the size of the plants and yield on the untreated plots ($r=+0{\cdot}62$ with 12 d.f.).

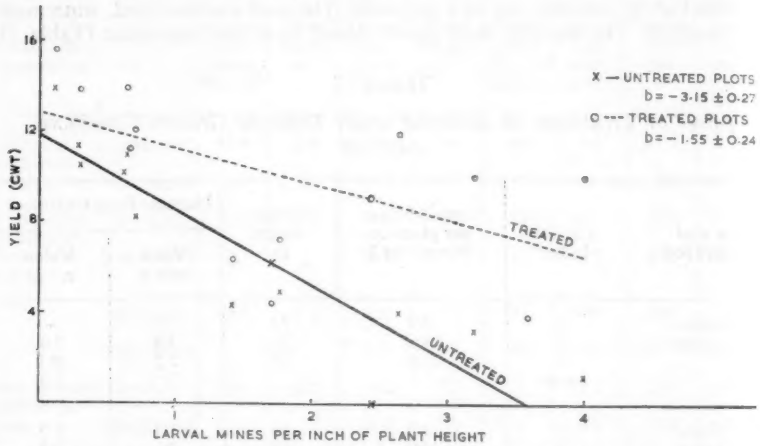

Fig. 2. Regression of yield of plots of coleseed on severity of cabbage stem flea beetle attack.

Separate trend lines have been calculated for the untreated and treated plots (Fig. 2). That for the untreated plots suggests that for every larval mine per inch of plant height there was a loss of 3·2 cwt of seed (from a potential yield of 12-13 cwt from undamaged crops). These figures are probably underestimates because some of the treated plots were sprayed when the crop was already seriously damaged.

As would be expected, the relationship between the yield of the treated plots and the attack on the corresponding untreated plots is not so close; the coefficient of correlation 0·55 approaches significance at $p=0{\cdot}05$, presumably due to the damage caused before the plants were sprayed. Treatment significantly reduced the regression coefficient from $-3{\cdot}15\pm0{\cdot}27$ to $-1{\cdot}55\pm0{\cdot}24$.

The unexpectedly large reduction of the yield of seed by cabbage stem flea beetle is the result of many plants being weakened or killed, and also some of the surviving plants, which have lost their main growing points produce several side-shoots which flower unevenly over a long period. Only part of the seed is then ready for harvesting at any one time and the yield from these plants is poor in both quantity and quality.

Another source of seed loss is the number of spring-hatched larvae which may occur after a mild winter as in 1957. These larvae are usually found feeding in the midribs of the leaves on the young inflorescence. As they grow, they migrate into the young side-branches formed in the axils of these leaves and eventually kill them.

SUMMARY

In East Anglia, over the years 1950-58, adult cabbage stem flea beetles were found to emerge in June, feed for some weeks and then undergo a period of aestivation from late July until mid-August, when they dispersed on to young brassica crops and recommenced feeding. Oviposition started in late August or September and continued throughout the autumn into winter. Larvae were found from September until the following April and pre-pupae and pupae from February until June.

The larvae were killed in the plants by a single application of *gamma*-BHC miscible liquid at 6 oz active ingredient per acre (3 pints of 10 per cent material) in 30-100 gal water; extra wetting agent was not needed. The treatment was applied during October, November, and December, and appeared to be effective at any time up to the end of the year.

With prices of seed and insecticide as in 1959, it would pay to spray coleseed whenever the cabbage stem flea beetle attack exceeds one larval mine per 3 in. of plant height (soil level to tip of longest leaf) before the end of the year. Where the crop is very dense or tall it is necessary to make an allowance for the mechanical damage caused by the sprayer; where there is much coleseed grown it would probably be worth while to spray by aircraft.

We wish to thank Dr. H. C. Gough for his advice at all stages of the work; our colleagues for their help with the field and laboratory work; the many growers who permitted observations and trials on their crops; Dr. R. M. Dobson for his help with translations of the literature and Mr. W. E. Dant for the photographs.

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SIZE AND PRICE INCREASE

In the ten years of its publication *Plant Pathology* has proved itself indispensable to research and advisory workers in this country, and is now widely read throughout the world. To give greater coverage of important work of particular interest to our readers, the number of pages in each issue will be increased to 48 (plus 4 pages of illustrations) as from Vol. 11 (No. 1), March, 1962.

We regret that in consequence, the price of single copies of *Plant Pathology* will be 7*s*. 6*d*. (7*s*. 10*d*. by post) as from March, 1962, and the subscription rate for four issues will be 31*s*. 4*d*. including postage.

Current subscriptions will be subject to the new rates on renewal.

EXTENT OF PROTECTIVE SPRAYING AND HAULM DESTRUCTION ON POTATO CROPS IN GREAT BRITAIN, 1952-60

by E. C. LARGE
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SINCE 1952 the Potato Division of the Ministry of Food, and latterly the Potato Marketing Board, have co-operated with the Plant Pathology Laboratory in potato blight survey work. For the purpose of ascertaining the extent to which protective spraying and haulm destruction is practised in Great Britain, advantage has been taken of a "crop-check weighing" scheme in operation for the estimation of potato yields. This work, of which some particulars have already been given in this Journal by Large and Honey (1955), is carried out on about 2,000 crops in England and Wales and 700 crops in Scotland each year. These crops provide a fair sample of all the maincrops and second earlies in England and Wales, and of the whole potato acreage in Scotland. In each year since 1952 a record has been made for each of the sample crops of whether or not it received *any* protective spraying or dusting, and also of whether the haulm was destroyed by acid, other chemical, or mechanical means. From 1958 onwards supplementary information on the number and type of protective applications has also been obtained.

A part of this information, for the years 1952-56, was employed by Large (1958) when estimating the probable losses in the several "blight zones" of England and Wales over a 10-year period. The acreage sprayed in each zone was then taken to be approximately proportional to the number of sprayed crops in that zone, as indicated by the crop-check records. Subsequent detailed examination of the acreage data for the years 1956, 1958 and 1960, however, has shown a bias in favour of more protective spraying and more haulm destruction on the larger fields in the country as a whole (Table 1). Weighting factors, as shown in this Table, have therefore been employed for conversion of percentage number of fields to percentage of acreage, for both England and Wales and Scotland in all years in the present estimates.

TABLE 1

Mean Sizes of Fields in Crop-Check Surveys, 1956, 1958 and 1960

	With Protective Spraying or Dusting	With Haulm Destruction by:				All crops
		Acid	Arsenites	Other Chemicals	Mechanical means	
Mean size of fields (acres)	11·2	11·9	10·7	9·7	10·2	9·5
Weighting factor	×1·18	×1·25	×1·13	×1·02	×1·07	×1·00

PROTECTIVE SPRAYING OR DUSTING

The percentage of the crop-check acreage in each year, from 1952 to 1960, which received *any* protective treatment (irrespective of number of applications) is shown in Table 2. In this Table the equivalents in thousands of acres are also given, taking the total maincrop and second early acreage in England and Wales to have been (in round figures) about 500,000 each year, and the total acreage in Scotland about 150,000. The available figures for mean number of applications in 1958, 1959 and 1960 are also given.

TABLE 2

Estimated Percentage of Crop-check Acreage, and Equivalent Total Acreages in Great Britain, which received any Protective Spraying or Dusting, 1952–60

	1952	1953*	1954*	1955	1956*	1957*	1958*	1959	1960*
Percentage of Acreage									
England and Wales	20	33	38	33	46	43	62	42	54
Scotland	16	32	38	30	36	37	40	31	38
Great Britain	19	33	38	32	44	42	57	39	50
Thousands of Acres									
England and Wales	100	165	190	165	230	215	310	210	270
Scotland	24	48	57	45	54	56	60	46	57
Great Britain	124	213	247	210	284	271	370	256	327
Mean No. of Applications									
England and Wales							2·7	2·3	2·7
Scotland							1·8	1·8	2·0
Great Britain							2·5	2·2	2·5

* " Blight years " (as defined in Large, 1958)

Before 1958 almost the whole of the protective spraying and dusting was done with copper fungicides. In 1958, however, non-copper dithiocarbamate materials (zineb and maneb) reached the stage of widespread trial use in England and Wales. In 1960, for the first time, a distinction was made between copper, non-copper, and mixed copper and non-copper spray programmes in the crop-check records. The break-down of the total sprayed or dusted acreage under these three heads in 1960, with mean numbers of applications (in brackets), was as follows:

Thousands of Acres, 1960	England and Wales	Scotland	Great Britain
Copper only	183 (2·6)	54 (2·1)	237
Non-copper only	63 (2·5)	3 (1·3)	66
Non-copper and copper	24 (3·4)	—	24
Total, sprayed	270	57	327

There was thus an indication that in 1960 about three-quarters of the protective spraying or dusting was done with copper fungicides, and one quarter with dithiocarbamates.

In 1959 and 1960 information was collected for all the crops in the crop-check surveys concerning the type and number of protective treatments given i.e., whether by air-spraying, ground-spraying, ground-dusting or by combinations of these methods. The estimated percentages of the acreage treated in each way, with mean numbers of applications, are presented in Table 3.

TABLE 3

Estimated Percentage of Crop-check Acreage Air-sprayed, Ground-Sprayed, and Ground-dusted in 1959 and 1960, with Mean Numbers of Applications (in brackets)

	Air Sprays only	Air Sprays + Ground Sprays	Air Sprays + Ground Dustings	Ground Sprays only	Ground Sprays + Ground Dustings	Ground Dustings only	All Methods
ENGLAND AND WALES							
1959 All varieties	6·8 (2)	1·7 (2+2)	0·3 (1+2)	22·6 (2)	0·7 (1+2)	9·9 (3)	42·0
1960 All varieties	9·8 (2)	2·6 (2+2)	0·7 (2+3)	29·2 (2)	1·9 (3+2)	10·2 (3)	54·4
King Edward	10·8 (2)	5·5 (2+2)	1·5 (2+4)	37·3 (3)	4·7 (3+2)	21·4 (4)	81·2
Majestic	9·0 (2)	1·3 (2+1)	0·2 (2+2)	24·3 (2)	0·9 (1+2)	6·6 (3)	42·3
SCOTLAND							
1959 All varieties	4·1 (1)	1·9 (1+1)	—	14·4 (2)	0·2 (2+2)	10·5 (1)	31·1
1960 All varieties	6·5 (2)	1·7 (1+1)	0·2 (1+1)	14·6 (2)	1·0 (1+2)	14·4 (2)	38·4

The amount of protective spraying done each year varies greatly according to the part of the country, and to the variety. In England and Wales there is much more spraying on the blight-susceptible King Edward (and Red King) than on the less susceptible Majestic. In 1960, King Edward occupied about 24 per cent of the total maincrop and second-early acreage in England and Wales, and of the King Edward crops about 90 per cent (by number) were sprayed or dusted in the Fens and East Anglia; 66 per cent in the East and West Midlands; and 52 per cent elsewhere. Of the Majestic crops, occupying in all about 58 per cent of the acreage, 50 per cent were sprayed or dusted in the Fens and southern coastal counties; 17 per cent in Yorkshire and Lancashire; 7 per cent in the North, and 36 per cent elsewhere. The percentages of the King Edward and Majestic acreages treated in the several different ways, in 1960, with the mean number of applications for comparison, are given in Table 3.

HAULM DESTRUCTION

Until 1952 almost all of the chemical haulm destruction in Great Britain was done with sulphuric acid. In that year, however, substitutes for sulphuric acid (for particulars of which see Large, 1952) began to come into use in view of a world shortage of sulphur supplies. These substitutes included tar oil fractions (fairly extensively used in Scotland) and sodium chlorate, but by 1955 sodium and potassium arsenites probably accounted for most of the chemical haulm destruction other than that done with sulphuric acid in England and Wales, and for at least half of that in Scotland. In the years

1953 to 1956, the use of sulphuric acid, or of "other chemicals" was noted; but it was not until 1957 that arsenites were distinguished from "other chemicals" in the crop-check records.

Table 4 presents the estimated percentages of the acreage in the crop-check surveys each year on which the several methods of haulm destruction were employed, using the weighting factors in Table 1 for conversion of percentage numbers of crops to approximate percentages of acreage in all years. The equivalents of these percentages, assuming a total of 500,000 acres of main-crops and second-earlies in England and Wales, and 150,000 acres of all varieties in Scotland, are also given.

TABLE 4

Estimated Percentage of Crop-check Acreage, and Equivalent Total Acreages in Great Britain on which Chemical or Mechanical Haulm Destruction was Employed, 1952–60

	1952	1953*	1954*	1955	1956*	1957*	1958*	1959	1960*
Percentage of Acreage									
ENGLAND AND WALES									
Sulphuric acid	9	15	17	5	17	16	20	15	24
Arsenites		5	8	5	17	13	26	16	13
Other chemicals						3	4	2	5
Mechanical	1	1	1	2	2	1	2	7	5
All methods	10	21	26	12	36	33	52	40	47
SCOTLAND									
Sulphuric acid	43	27	13	9	16	14	15	19	28
Arsenites		27	35	29	34	14	16	17	7
Other chemicals						13	18	10	16
Mechanical	16	8	8	15	11	13	12	27	21
All methods	59	62	56	53	61	54	61	73	72
Thousand of Acres									
ENGLAND AND WALES									
Sulphuric acid	45	75	85	25	85	80	100	75	120
Arsenites		25	40	25	85	65	130	80	65
Other chemicals						15	20	10	25
Mechanical	5	5	5	10	10	5	10	35	25
All methods	50	105	130	60	180	165	260	200	235
SCOTLAND									
Sulphuric acid	65	40	20	14	24	21	22	28	42
Arsenites		41	52	44	51	21	24	25	11
Other chemicals						19	27	15	24
Mechanical	24	12	12	22	17	20	18	41	31
All methods	89	93	84	80	92	81	91	109	108
GREAT BRITAIN									
Sulphuric acid	110	115	105	39	109	101	122	103	162
Arsenites		66	92	69	136	86	154	105	76
Other chemicals						34	47	25	49
Mechanical	29	17	17	32	27	25	28	76	56
All methods	139	198	214	140	272	246	351	309	343

* Blight years.

In 1960 haulm destruction was carried out on about half of the King Edward crops in England and Wales, and on about one-third of the Majestic. In Yorkshire, Lancashire and the North, and also in the South-west, the proportion of the crops of all varieties on which haulm destruction was practised was about a quarter; in the Midlands and around the Wash it was about a half; and in Kent and Essex it was two-thirds.

This opportunity is taken of thanking all the Area Officers of the Potato Marketing Board who took part in the recording or reporting of survey data over the years of this work.

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A NEW LOCAL LESION ASSAY METHOD FOR TOMATO SPOTTED WILT VIRUS, WITH A NOTE ON CYCLICAL CHANGES IN INFECTIVITY

by I. W. SELMAN *and* R. G. MILNE

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Nicotiana tabacum has been used for many years as a local lesion assay host for T.S.W.V., e.g., Samuel and Bald (1933), although Smith (1932) suggested the use of *Petunia*. *Nicotiana tabacum* takes several weeks to reach a convenient size and the plant can be used on one occasion only for assay. It has few suitable leaves and these differ considerably in susceptibility. These qualities make it unsuitable for use in small growth-rooms.

A method has been developed in which leaf strips cut from young, expanded leaves of a clone of *Petunia hybrida* are inoculated with tomato spotted wilt virus and incubated in petri dishes. Maintenance of *Petunia* plants is easy, propagation is rapid and large numbers of plants are not required, for many comparable leaves can be removed for assay purposes, over several weeks, from one batch of plants.

A strip 8×18 mm is removed from one half of a leaf with a cutter made of razor blades. Strips are placed on two layers of wet filter paper round the margin of a 12 in. disc on a gramophone turntable. Approximately 0·15 ml of inoculum is placed on each strip and spread without touching the leaf surface with the pipette. The precise volume of inoculum is unimportant so long as the surface is completely wetted. Maximal lesion production is obtained by adding 1 per cent of celite by weight (B.D.H., grade 535) to the inoculum.

The turntable is rotated at 1 r.p.m. and the strips pass once under a pivoted ground glass roller weighing 200 g (Plate I, 2 *left*). The strips are incubated on moist filter paper in a closed dish in the light for 3 days in a growth-room

at 18·5°C. With light intensities of not less than 400 ft candles during a 15 hr photo-period, well defined lesions are formed (Plate I, 2 *right*), but in darkness no lesions appear unless sucrose is supplied.

The difference in lesion production between halves of the same leaf is not significant and differences between leaves cannot be related either to position on the plant or to plants within a batch, if senescent leaves and those less than 35 mm long are not used.

As a comparison between finger and roller inoculation, two strips were cut from each of 40 leaves and one of each pair was inoculated with the finger and one with the roller, using T.S.W.V. in tomato leaf sap diluted with sodium sulphite and kept at 0·5°C. Batches of 10 strips were inoculated at a time. Lesion counts are shown in Table 1.

TABLE 1

Comparison of Finger and Roller Inoculation

Batch	No. of lesions per leaf strip (means of 10)	
	Finger	Roller
1	6·1 ± 1·9	34·0 ± 1·3
2	5·4 ± 0·8	29·8 ± 2·3
3	3·3 ± 0·3	31·7 ± 1·6
4	4·5 ± 1·4	34·8 ± 2·6

Many more lesions were thus obtained with the roller than with the finger, using the same inoculum. If dilutions of infective sap were adjusted to give comparable lesion numbers with finger and roller inoculation, the coefficient of variation was less with the roller. Thus, with counts ranging from 33 to 45 lesions per strip (means of 10), the coefficient of variation was reduced from 20 to 6 per cent.

Lindner and Kirkpatrick (1959), who used an "airbrush" or atomiser to inoculate cucumber cotyledons with tobacco mosaic virus, also obtained more lesions for a given inoculum, and a smaller coefficient of variation, in comparison with the conventional method of "rub" inoculation.

CYCLICAL CHANGES IN INFECTIVITY IN TOMATOES INOCULATED WITH T.S.W.V.

A decrease in infectivity following initial multiplication of T.S.W.V. has been noted by Samuel and Bald (1933) in tomato and by Black (1955) in *Nicotiana rustica*. The production of symptom-free leaves has been noted in glasshouse tomatoes inoculated with T.S.W.V. 28 days after the first appearance of systemic symptoms (Selman, 1943). Twelve days later symptoms reappeared on the young leaves. Studies with tomatoes in growth rooms in this department have also revealed a cycle of symptom intensity. Using the technique described above, changes in infectivity have been studied for periods up to 64 days following inoculation with T.S.W.V.

All the plants used were grown at a constant temperature of 18·5°C and a daily light period of 15 hr provided by 80-watt "warm white" fluorescent tubes giving a light intensity of 450 ft candles. The virus used was a strain of T.S.W.V. originally obtained from Dr. K. M. Smith of Cambridge and resembling in virulence strain D of Best and Gallus (1953). It was maintained

in young tomato plants (cultivar. " Potentate ") grown in water culture and was transferred to new plants every two weeks. The tomatoes were raised in boxes of sterilized John Innes seed compost and transferred to water culture when the first true leaf was expanding. The nutrient solution was that used by Selman and Grant (1957), supplemented with $NaNO_3$ to bring the N level to 316 p.p.m. The plants were grown in 3-litre troughs lined with polythene; 11 cm deep, 8 cm wide and 37 cm long.

After one week in water culture, the first two foliage leaves were inoculated using the finger method. Inoculum was prepared from leaves which had been inoculated two weeks earlier. One part by weight of leaf was ground up with two parts by volume of 0·5 per cent hydrated sodium sulphite (dilution 1:2) and cell debris removed by filtration through muslin. Celite was added to the extract to give a 0·2 per cent w/v suspension. This mixture was the " standard inoculum " which varied little in activity from week to week.

Systemic symptoms appeared 7-8 days after inoculation and stem growth was severely checked for 6-7 days. Thirteen-fourteen days after inoculation, the rate of stem growth increased markedly, leaf symptoms became milder and 4-5 weeks after inoculation, symptom-free leaflets were produced. One-two weeks after this time characteristic systemic symptoms reappeared.

In the first experiment, changes in infectivity in inoculated leaves, tip leaves, stems and roots were studied over a period of 19 days, following inoculation with infective sap at two dilutions. 180 plants were inoculated on the first two foliage leaves, one half with sap at dilution 1:2 (I_2) and one half at dilution 1:10 (I_{10}).

Plants were sampled for assay on 11 occasions from the 3rd to the 19th day following inoculation. Two independent samples were taken from each treatment; on days 3 and 5 there were 5 plants per sample and thereafter 3 plants per sample. The samples were divided into stem, leaf and root (including hypocotyl) and 0·5 g of each fraction was converted to inoculum at dilution 1:20, with the inclusion of 0·2 per cent of celite by weight. In practice, this dilution and amount of celite gave a satisfactory range of lesion numbers on the *Petunia* strips, throughout the period of sampling. Assays were made on 10 leaf strips immediately after sampling. The lesion counts are summarized graphically in Fig. 1.

It was thus possible to distinguish differences in infectivity associated with level of inoculum, three days after inoculation of the first two leaves and until the 8th day when systemic symptoms appeared. For 7-9 days after inoculation the effect of inoculum dilution could be detected in tip leaves and stems, but after this time infectivity was similar with the two treatments.

Infectivity reached a maximum 11 days after inoculation in leaves and stems, and then declined rapidly in tip leaves and stems to the 19th day. Inoculated leaves showed only a slight falling off in infectivity during this period. The infectivity of the roots was very low at all times. The low infectivity of roots is probably accounted for by the presence in root sap of substances which inhibit lesion production by infective sap on *Petunia* leaves. Leaf sap however, causes little or no inhibition. Anomalous dilution curves have been obtained for infective root sap (Milne 1960) which also indicated that inhibitors may be present. In view of this possible interference from inhibitors, the experiment was repeated using sap dilutions for assay of 1:5 and 1:65, with closely parallel results.

In two further experiments the infectivity changes taking place in tip leaves were followed: (i) from day 22-23 and (ii) from day 34-64. In these experiments

the tomatoes were inoculated with infective sap at dilution 1:2, but at the time of inoculation the plants were slightly larger than in the first experiment. The infectivity changes for the three experiments are summarized in Fig. 2. The cyclical changes in symptoms are thus closely paralleled with changes in infectivity.

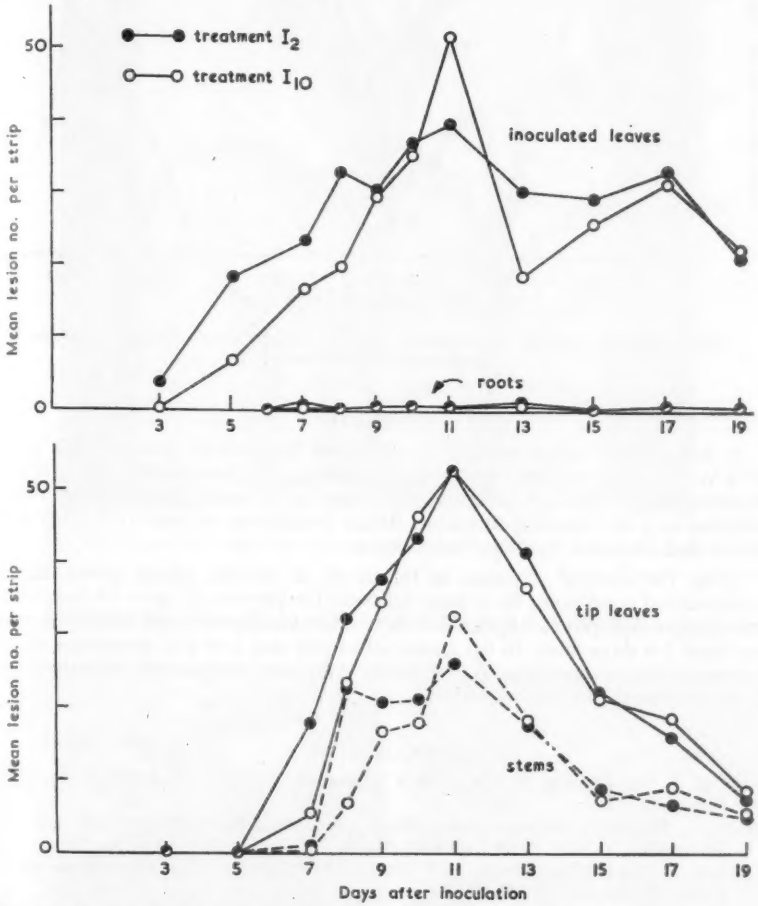

Fig. 1. Infectivity of inoculated leaves and of roots, tip leaves and stems of tomato assayed at dilution 1:20 with 0·2 per cent celite.

With some perennial hosts of T.S.W.V., such as *Zantedeschia, Dahlia* and *Chrysanthemum*, the apparent "recovery" of infected plants has been occasionally noted (e.g. Selman 1944) and it is of interest to find that infected tomatoes may also show the phenomenon. The factors which control these changes are still unknown.

In view of the differences which may exist in infectivity between parts of the same plant, it is recommended that when testing for T.S.W.V., old and young leaves should be examined separately.

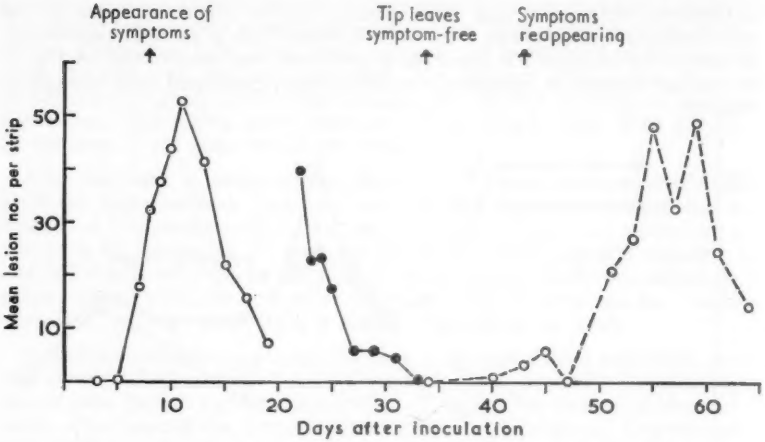

Fig. 2. Cyclical changes in infectivity of tip leaves of tomato (Data from three independent experiments).

SUMMARY

A local lesion assay method is described for tomato spotted wilt virus (T.S.W.V.) using excised leaf strips cut from a clone of *Petunia hybrida*. Inoculation is effected mechanically using a pivoted ground-glass roller attached to a slow-moving turntable. Roller inoculation reduces variability well below that obtained by finger inoculation.

Using the method, changes in infectivity in tomato plants grown under standardized conditions, have been followed for periods of up to 64 days after inoculation. Symptoms appeared 8 days after inoculation and infectivity was maximal 3-4 days later. In tip leaves infectivity was low and symptoms slight 4-5 weeks after inoculation. At 7-8 weeks symptoms reappeared and infectivity again increased to a high level.

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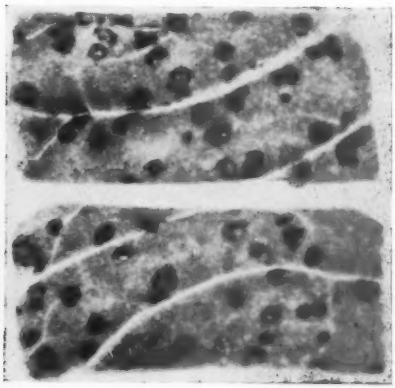
FRIT FLY IN MAIZE (see p. 125)

1. *Left:* Plant severely attacked; *centre:* healthy plant; *right:* moderately attacked.

Photo: Harper Adams Agricultural College

ASSAY METHOD FOR TOMATO SPOTTED WILT VIRUS (see pp. 100-4)



Photos: R. G. Milne

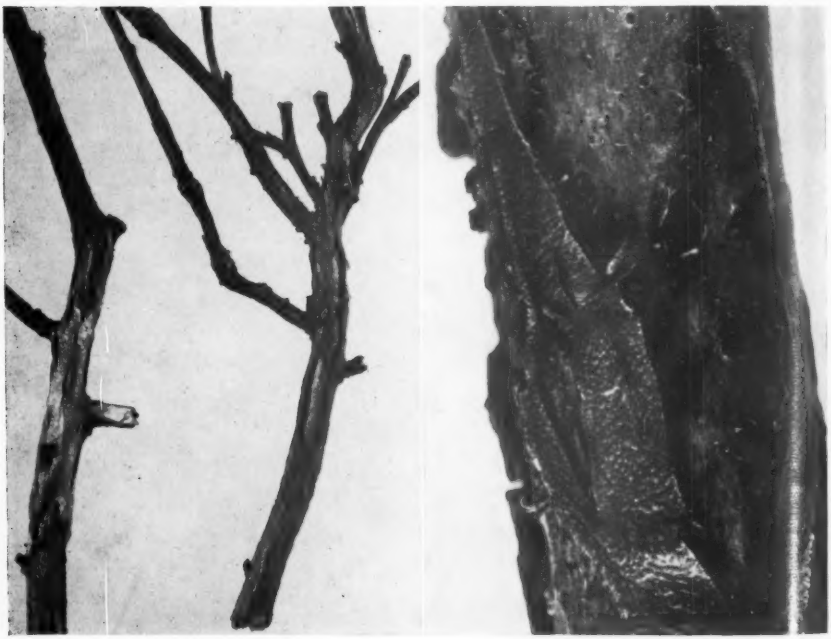
2. *Left:* Roller and turntable for inoculation of *Petunia hybrida* leaf strips, and *(right)* resulting local lesions.

DAMAGE TO STORED APPLES BY *THUJA* WOOD (see pp. 116 3)

Photo: Ministry of Agriculture, Northern Ireland

1. Apple after three months barn storage in box made of unseasoned Western Red Cedar, *Thuja plicata*.

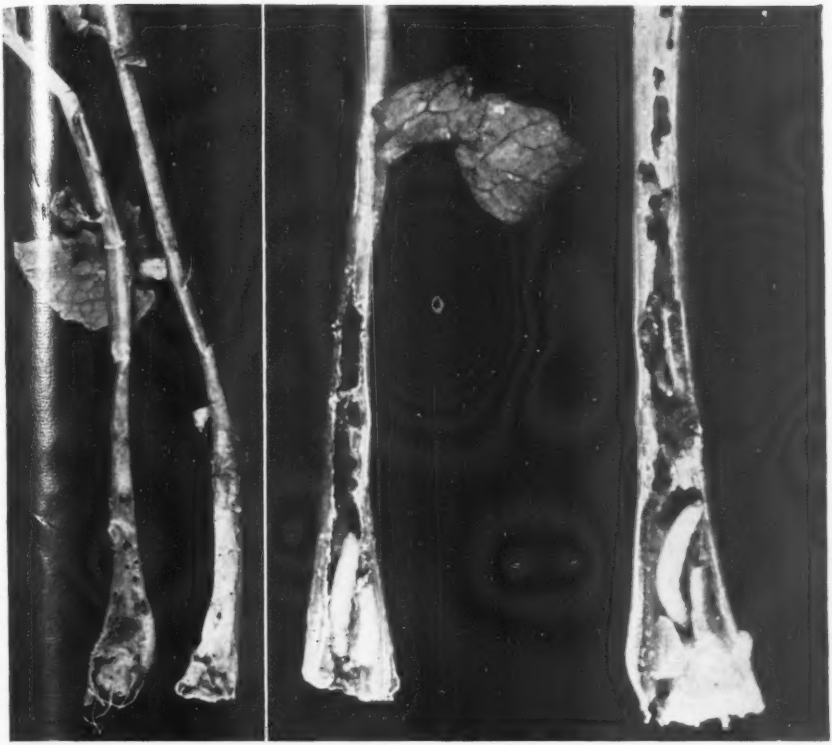
FUNGI ON HIGHBUSH BLUEBERRIES (see p. 123)



Photos: Scientific Services, East Craig

2. *Left:* cankered twigs; *(right):* canker with fructifications of *Crumenula urceolu*

PLATE II



1. Swede leaf petioles *(left)* showing holes above larval mines and *(right)* cut open showing larvae *in situ*.

2. Infested coleseed crop showing plot sprayed with *gamma*-BHC and unsprayed plot in foreground.

SOILS OF APPLE ORCHARDS NEAR WISBECH

1. Typical grassed orchard (H) $\times\frac{1}{2}$

2. Orchard AB with much copper in soil, showing surface mat $\times\frac{1}{2}$

3. Grass field beside orchard AR $\times\frac{1}{2}$

Photos: Rothamsted Experimental Station

4. Orchard AR with much copper in soil, showing surface mat $\times\frac{1}{2}$

PLATE IV

COPPER ACCUMULATION IN THE SOILS OF APPLE ORCHARDS NEAR WISBECH

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DURING epidemiological studies of apple scab, *Venturia inaequalis* (Cooke) Wint., in the Wisbech area of Cambridgeshire (Hirst, Storey, Ward and Wilcox, 1955), soils of some orchards on one holding were found to be atypical and unusually rich in copper. This paper compares the soils of two atypical orchards (AB and AR) with typical soils from five grassed and two arable orchards on other holdings, all within five miles of Wisbech. Orchard AR had been used for an experiment to test what effect different amounts of the sodium salt of dinitro-ortho-cresol had on the number of ascospores liberated from leaves which had overwintered on the ground. The soil of these plots was later sampled to find whether the treatments had affected the earthworm population, but the results were inconclusive as very few worms were found in treated or untreated plots. During sampling Mr. J. W. Stephenson noticed that the soil profile was atypical of grass-covered apple orchards in the area, and further work suggested that plant-protective chemicals, particularly Bordeaux mixture, may have modified the soil.

SOILS AND ORCHARD MANAGEMENT

Soils of the reclaimed fenland around Wisbech are all of estuarine origin. Surface peat deposits are rare, although a thin (3-12 in.) peat layer extends over much of the area at depths varying from 3 to 10 ft. The silts vary erratically in mechanical analysis over the district and beneath some orchards there is stratification of fine and coarse deposits (Wright and Ward, 1929).

All orchards were planted with the variety Bramley's Seedling between 40 and 60 years ago. Initially apples were inter-planted with soft- or bush-fruit and sprayed lightly using hand lances from hand-operated pumps. Increasingly severe attacks of apple capsid and scab led first to the introduction of stationary motor pumps and then tractor-drawn sprayers, which necessitated the removal of the undercrops and towards the end of World War II most orchards were allowed to "tumble down" to grass.

Rates of spraying further increased in the early 1950's when the apple scab attacks became more severe than previously (Storey and Ives, 1956). Finally, the introduction of the phenyl mercury compounds has recently allowed the number of fungicide applications to be decreased. All orchards had been exposed to a wide range of plant-protective chemicals including tar oil and DNOC winter washes, lead arsenate and lime sulphur. Growers' records and recollections showed only one consistent difference between the treatment of the typical orchards and those on the holding where copper has accumulated, and this was the amount of Bordeaux mixture applied. The substitution of Bordeaux mixture for most of the more usual lime sulphur sprays improved the control of apple scab and gave equally high yields. Fig. 1 shows the amount of copper applied in Bordeaux mixture to orchard AB (orchard AR was similar). Typical orchards like H (Table 1) have received fewer and smaller applications and the weight of copper applied annually has probably ranged from none (or more usually from 2 lb) to 9 lb per acre until 1955, when the use of Bordeaux mixture ceased.

All orchards were well supplied with major nutrients and had soil pH values not far from neutral. Typical grassed orchards, for example orchard H (Plate IV, 1), had well developed crumb structure with numerous earthworm burrows penetrating the surface beneath the grass. Their copper contents as shown by spectmographic analysis agreed in general with the amount of Bordeaux mixture known to have been applied; they ranged from 16 p.p.m. in orchard G where no copper has been used, to 98 p.p.m. in orchard C. Soil profiles from the copper-rich orchards AR and AB (Plate IV, 2 and 4) both showed a surface peat mat, ½-1½ in. thick. This horizon contained most of the grass roots and could often be rolled off the surface of the underlying mineral soil like a carpet. The mat was thickest beneath the branches of the trees. The upper layers were composed of leaf fragments in various stages of decomposition, and the lower layers were chiefly composed of insect faecal pellets (Dr. D. A. Osmond, *in lit*). Particularly on the heavier silt of orchard AR the mineral soil was densely compacted, with less crumb than orchard H, and penetrated by few burrows or roots of herbaceous plants. However, the most striking feature was the copper content of the surface mat, where concentrations reached 2,500 p.p.m. of air-dried material. By contrast, a grass field adjoining orchard AR had a pronounced crumb structure and no surface mat (Plate IV, 3). This was also true of adjacent dessert apple orchards where no Bordeaux mixture had been applied. Analyses (Table 1) showed that the grass field had the lowest pH, and that the top 4 in. of mineral soil had about the same amount of organic matter as the typical soils of grassed orchards but more copper than some.

TABLE 1

Analyses of Orchard Soils at Wisbech (air-dry basis)

Orchard	Cultivation	Depth of sample *in.*	pH	Organic carbon *per cent*	Loss on ignition *per cent*	Copper *p.p.m.*
WISBECH:	AR Grass	Mat	6·0	27·8	40·0	>1500
		0–4	6·3	2·6	8·4	120
	AB	Mat	6·6	22·6	--	2500
		0–4	7·2	2·5	–	150
		4–8	7·2	1·8	–	33
	C Grass	0–4	6·6	–	11·3	98
	H Grass	0–4	6·8	–	8·5	39
	G Grass	0–4	6·3	–	6·0	16
	KB Grass	0–6	6·6	3·5	–	18
	KR Grass	0–6	7·5	2·3	–	14
	B Arable	0–6	7·7	2·9	–	47
	W Arable	0–6	7·3	2·6	–	44
Grass field beside AR		0–4	5·8	–	13·3	39

DISCUSSION

Growers' records gave no evidence of important differences between the management of the holdings with copper-rich soils and other orchards in the district except in the amount of copper applied. Where much copper remained, presumably fixed to organic matter (Broadbent and Ott, 1957), there was no proof that this was the cause of the soil modification. The cause might have been lead, arsenic or other toxic residues for which we did not test. The evidence, however, points to copper as having been responsible, and it seems justifiable to present the facts in the hope that they may stimulate experiments and search for similar accumulations elsewhere. Furthermore, the development of the surface mat and the reduction of crumb structure were difficult to explain

except as the result of an interaction between the copper and biological activities within the soil. It may therefore be helpful to speculate about the result of such interaction; also to estimate the amount of copper applied and how long the process has been operating.

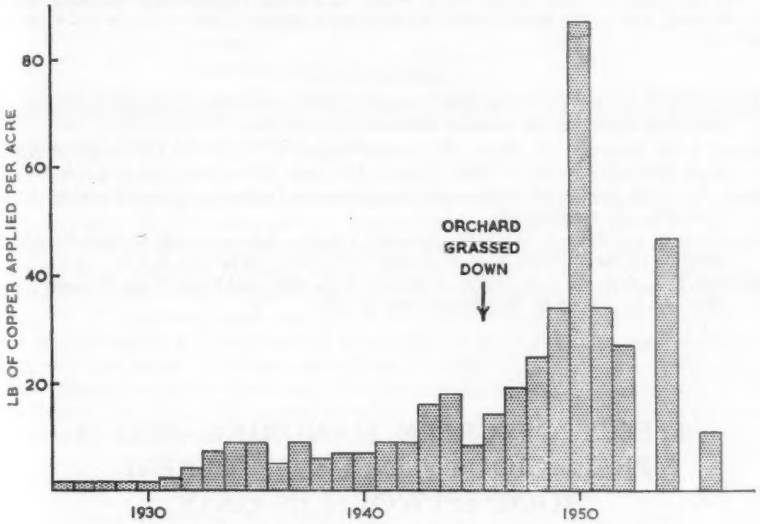

Fig. 1. Weight of copper applied each year in Wisbech orchard AB.

Variable strengths of Bordeaux mixture have been used; in orchard AB the original formula was 3-10-40 but in later years it has averaged 9-12-100 and this has been used as a basis for calculating the amount of copper applied. From 1926 to 1960 approximately 430 lb of copper were applied per acre. Of these 300 lb per acre or 1 oz per sq. yd. followed grassing-down in 1945-46. Although the copper content of the soils may have increased while the orchards were cultivated annually, the accumulation of the surface mat can only have started when an undisturbed grass cover was established. One old Bramley's Seedling orchard under arable cultivation and close to orchards AR and AB was grubbed out in 1945 and replanted with dessert varieties and a grass cover. The replanted varieties are intolerant of Bordeaux mixture, so no copper has been added since 1945. Significantly, this orchard now has good soil structure and no surface mat. The evidence suggests that the normal processes by which litter is removed and destroyed were interrupted in orchards AR and AB, perhaps because the organic matter had become toxic to the animals or micro-organisms which usually cause its disappearance. This could be tested experimentally within a reasonable number of years assuming that 300 lb of copper per acre were applied over a period of about 15 years, during which time the grass cuttings and fallen apple leaves accumulated. Biological investigations to be described by others (Raw, 1962) help to indicate the probability of the hypothesis being correct.

SUMMARY

The soils of two apple orchards near Wisbech where there were unusually few earthworms, also had an atypical peaty surface mat and poor crumb structure. Exceptional amounts of Bordeaux mixture had been used in both

orchards since 1926 and in one 300 lb per acre of copper had been applied since grassing down in 1945. Analyses showed over 1,500 p.p.m. Cu in their surface mats and over 120 p.p.m. Cu in the top 4 in. of soil.

We are much indebted to Mr. W. C. Ward, the District Horticultural Advisory Officer in Wisbech, and to the growers who allowed us to examine their orchards and spraying records.

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EFFECT OF GREEN MANURING AND A PREDACIOUS FUNGUS ON CEREAL ROOT EELWORM IN OATS

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IN previous trials (Duddington and Duthoit, 1960) green manuring with chopped cabbage leaves reduced the numbers of larvae invading the roots of oat seedlings grown in soil infested with *Heterodera avenae* Woll. It has been suggested (Linford, 1937; Duddington and Duthoit, 1960) that green manuring may stimulate predacious fungi naturally present in the soil to greater activity, with consequent reduction in larval eelworm populations. Our earlier trials were on spring oats, and in the autumn of 1956 a further trial was laid down at the Wolverhampton regional N.A.A.S. headquarters to see whether similar results could be obtained with winter oats. At the same time the treatment range was extended to include soil inoculation with a predacious fungus.

Six replicates of four treatments were applied to plots 2 ft square on ground known to be infested with *H. avenae*: 4 oz per plot of wet mycelium of *Dactylaria thaumasia* Drechsler, worked into the top soil with 1 lb of fresh grass mowings; mycelium without grass mowings; grass mowings without mycelium; and untreated control. The treatments were applied on October 25, and the plots, all of which received a dressing of N.P.K. fertiliser, were drilled with S.147 oats in two parallel rows on the same day. The plots were left untouched through the winter, were thinned on February 22, and on March 26, 1957, all plants were lifted, special care being taken to avoid root injury.

After lifting, five plants were taken at random from each plot and their roots were stained with acid fuchsin in lactophenol after gently washing away as much of the soil as possible. Each root system was then blotted between

filter papers and weighed, after which the numbers of invading *H. avenae* were counted. The mean numbers per gramme of root estimated from 30 roots per treatment were:

Fungus + green manure	98
Fungus only	97
Green manure only	157
Untreated	235
Significant Difference (p=0·05) ...	55·5

Fungus and green manure, separately and combined, differed significantly from the untreated plot results, and fungus alone and combined differed significantly from green manure alone.

In 1958 a similar trial was made on spring oats (Sun II, sown on April 2) in a field at Pattingham, Shropshire, known to be heavily infested with cereal root eelworm. Six replicates of four treatments were applied to plots 3 ft by 2 ft in size: 1 oz of wet *Dactylaria thaumasia* mycelium worked into the top soil with 0·5 lb of chopped cabbage leaves; fungus without chopped cabbage; autoclaved mycelium with chopped cabbage; and autoclaved mycelium only. The quantity of mycelium used was found to be equivalent to less than 0·2 g of dry organic matter per plot, and all plots received an N.P.K. dressing equivalent to 3 cwt per acre. Seedlings were lifted on May 5, and five sample plants were taken at random from each plot for examination in the same way as in the winter oat trial. The mean number of *H. avenae* per gramme of root estimated from 30 roots per treatment were:

Live fungus + chopped cabbage ...	127
Live fungus only	254
Autoclaved fungus + chopped cabbage	370
Autoclaved fungus only	408
Significant difference (p=0·001) —	110·5

The first three treatments differed significantly, and the first two treatments differed from the fourth, at the 0·1 per cent level.

In both trials evidence of the effect of the fungus in reducing the invasion of oat seedlings by eelworm larvae was obtained, and the effect of the fungus, with or without green manuring, was significantly greater than that of green manuring alone. In the second trial green manuring without fungal inoculation failed to reduce eelworm invasion appreciably. This was at variance with the result of the first trial, and with the trials reported in our 1960 paper. It may have been due to deficiency in the natural predacious fungal flora at Pattingham, but this possibility was not investigated.

It has been suggested (Jones, 1958) that, in previous trials on the control of eelworm by predacious fungi, the effects may have been due to the manurial value of the large amounts of fungal mycelium used. This cannot apply to the 1958 trial, where the amount of organic matter in the mycelium was negligible, and the control plots received an equivalent amount of autoclaved material.

We thank Mr. H. C. F. Newton and Mr. A. W. Marden for providing some of the facilities for this work, and Miss S. Ardley, Miss K. Taylor, and Dr. D. Priest for technical assistance. The 1956-57 trial was made partly with the aid of a special research grant from the Agricultural Research Council.

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TRIALS ON CARROT FLY CONTROL IN NORTH-EAST SCOTLAND 1956-58

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SINCE the introduction of BHC, its effectiveness in controlling carrot fly in the British Isles has been well shown by the work of Newton, Satchell and Shaw (1946), Wright (1951), Shaw (1952), Shaw and McDonald (1955), MacLagan (1955) and Stone (1956). However, the tendency for BHC, under certain conditions, to impart taint to carrots has led to it being replaced by dieldrin, which the recent work of Wright (1958, 1959 and 1960) has shown to be as effective as BHC, and also to have the added advantage of being non-tainting.

During 1956-58, field experiments on the control of carrot fly were undertaken in the Horticultural Unit of the College of Agriculture at Craibstone, Aberdeen, with a view to investigating the control of carrot fly within crops left *in situ* all winter. This practice is common in certain areas of N.E. Scotland, and in some years extensive carrot fly injury occurs during the winter months.

A trial of various insecticidal treatments and control, was laid down in each of the three years on a different area within the same field. None of the areas concerned had previously received any soil insecticides. All spray applications were applied by a knapsack sprayer, the spray being delivered on the rows, at a constant pressure of 40 lb per square inch. Applications of dust were made by means of a small pepper pot, this being found to give the most uniform distribution over the small areas involved.

Throughout the series, the carrot variety was Chantenay, sown in rows 18 in. apart by means of a Planet junior drill at approximately 4 lb per acre.

The carrots were never thinned, this being common commercial practice in the area. Following germination, all plots in each year were treated with a suitable weed oil at 40 gal per acre to control annual weeds.

TRIAL IN 1956–57

This trial was sown on April 18, 1956, and included all 24 combinations of six treatments (as shown in Table 1) and four dates of lifting. A split-plot design with four complete replications was used. The main plots with lifting date treatments were arranged in a 4×4 Latin square and within each main plot the 6 insecticide treatments were assigned at random to the six sub-plots. Each sub-plot was 2 yd wide by 4 yd long, with a yard gap between main plots.

Unfortunately the resurgence of a local rabbit population which had been substantially reduced by myxomatosis, caused extensive damage to the upper portion of root during January-March, 1957. This made it impossible to obtain accurate results for the fourth sampling in March, 1957.

The sampling area for each sub-plot consisted of the middle three yards of the two centre rows. Thus each outer row and 18 in. at the end of each row within each sub-plot was a buffer area. All carrots in the sampling area

were lifted, washed and examined for carrot fly injury. All were classified into two categories, clean or damaged, a clean carrot being one showing no external signs of damage by carrot fly larvae.

For each sub-plot the number of clean carrots was expressed as a percentage of the total number lifted (Table 1). Because of the wide range of percentages angular transformation was employed to allow an analysis of variance and tests of significance to be carried out. A complication in this analysis was the fact that one of the main plot treatments (the fourth lifting date), was missing. The figures presented in Table 1 have been transformed back to percentages of clean carrots from the mean values in degrees.

TABLE 1

Results of Trial in 1956

Treatment	Oz active material per acre	Date of spraying	Mean No. of plants per 6 yd of row June 30 ±10·8	Percentage of Clean Carrots			
				Aug. 4	Sept. 28	Dec. 3	Mean
Control	–	–	154	79·4	53·8	52·3	62·6
Dieldrin .... 2 sprayings ...	3 9	June 13 Aug. 6	176	88·5	63·6	79·7	78·1
Gamma-BHC On seed* + 1 spraying ...	8	Aug. 6	117	93·1	91·8	88·3	91·2
Dieldrin On seed† + Chlordane 1 spraying ...	16	Aug. 6	205	93·3	84·9	82·4	87·3
Gamma-BHC 1 spraying + ... Chlordane 1 spraying ...	4 24	June 13 Aug. 6	153	87·8	86·4	79·1	84·6
Dieldrin 2 sprayings	6 12	June 13 Aug. 6	182	78·0	82·5	88·1	83·1
Means				87·3	78·5	79·2	

* Seed treatment 1 oz 50 per cent *gamma*-BHC per lb on April 18

† Seed treatment 1 oz 75 per cent dieldrin per lb on April 18

TRIAL IN 1957–58

This trial was sown on April 29, 1957. Two replications of a split-plot design were used, the main plot treatments being three dates of lifting, and within each main plot the 14 sub-plots contained 12 insecticide treatments and two controls (as shown in Table 2). Plot size and area sampled were the

same as in 1956. An analysis of variance and tests of significance were carried out on transformed values of the percentage of clean carrots as in 1956. Since the level of the second application of an insecticide had no effect the mean values for pairs of treatments are presented in Table 2.

TRIAL IN 1958

This trial was sown on May 2, 1958. The same type of experimental layout was designed to test the same set of treatments as used in 1957. The first lifting took place on September 24. Since the differences between the insecticide treatments and the control were small and not significant, and since the local population of adult carrot flies was extremely low throughout the year (Fig. 1), it was considered that further observations would not provide any useful information.

In 1956 and 1957 plant counts were made of the sampling area in each sub-plot. The mean values of counts on June 30, 1956, are given in Table 1 and those on August 1-2, 1957, in Table 2.

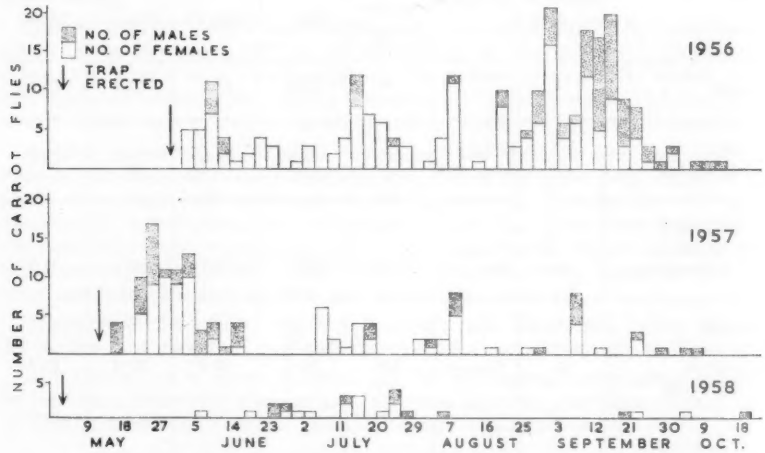

Fig. 1. Numbers of carrot flies trapped in 1956, 1957 and 1958.

TRAP OBSERVATIONS

In order to give some indication of the period of adult activity and thus be able to apply relevant insecticides at the best time to obtain maximum control, four sticky traps were placed at random within the pathways between the blocks of plots.

These traps consisted of circular pieces of Perspex $\frac{1}{8}$ in. thick, 14 in. in diameter and so shaped that the centre was $\frac{1}{2}$ in. higher than the circumference. They were placed on a base of galvanized sheeting and help in position by means of a galvanized ring 1 in. wide. The whole trap was fixed to a wooden pole and placed at a height of 3 in. from the ground (Fig. 2). The traps had been used originally for aphid investigations within the potato crop and both the under-surface of the Perspex and the upper surface of the galvanized base were painted yellow. Throughout the major period of adult activity during the three years, the traps were examined every three days, being changed after each six-day period and a fresh coating of grease-banding

material applied. At each examination carrot flies were removed by means of a spear-pointed needle and placed in tubes containing a 50/50 mixture of ethyl acetate and glacial acetic acid. These flies were examined and sexed at a later date in the laboratory, the number caught being depicted in Fig. 1.

Fig. 2. Cross section showing construction of 14-inch-diameter traps.

DISCUSSION

In some respects it is unfortunate that the trials coincided with a reduction in carrot fly population in the area of the trials. This is well seen in Fig. 1, where the same trapping technique over the three years indicated a substantial reduction in adult numbers. The reasons for this are unknown. It is probable that natural factors, such as an increase in the population of natural predators may have been partially responsible. Also the fact that five-sixths of the experimental area was treated with insecticide in 1956 and six-sevenths in 1957 and 1958, may have been a contributory factor in reducing the fly population. Within an area where substantial control of a pest is being obtained the overall effect in consecutive years must be quite pronounced, even though a reduction in a certain proportion of predators, due to application of insecticides, would tend to permit a resurgence of the pest species. During the period, few cases of economic damage by carrot fly were noted throughout north-east Scotland, but here again one must consider that the majority of growers, both commercial and amateur gardeners, take adequate precautions against attack.

The effect of the seed dressings on germination in 1956 was that BHC gave a reduction, whereas dieldrin gave an increase compared with the control area (Table 1). There were no real differences between the other four treatments. In 1957 no significant differences were apparent between any of the treatments and control (Table 2).

Throughout the trials over 27,000 carrots were washed and examined for damage. In 1956 a comparison between dates of lifting showed the percentage of clean carrots to be higher at the first date than at the two later dates of lifting (Table 1), which was no doubt due to the influence of the second generation. This period, compared with any other over the three years, had the highest concentration of adult flies (Fig. 1).

Averaged over the three lifting dates, the percentage of clean carrots was significantly lower with the control treatment than with the other five treatments (Table 1). A *gamma*-BHC seed dressing followed by a spray of 8 oz *gamma*-BHC per acre gave the highest percentage of the 5 insecticidal treatments, and the low rate of dieldrin applied as a spray at 3 oz active material per acre followed by 9 oz per acre gave the lowest. This was no doubt due to a very low rate of dieldrin which was introduced to try to determine the minimum rate of active material consistent with a substantial degree of control. Wright (1959) found in 1957 that a minimum of $\frac{3}{4}$ lb per acre of dieldrin, when rotovated into the soil, was necessary to give satisfactory control in a normal season, although in 1958, probably due to the cool, moist soil conditions, $\frac{1}{2}$ lb per acre gave complete control of a moderate fly population on a medium loam type of soil.

TABLE 2

Results of Trials in 1957 and 1958

Material	Oz active material per acre	Dates of spraying or dusting		Mean No. of plants per 6 yd of row Aug. 1–2 1957 ± 5·7	Percentage of clean carrots				
					1957–8				1958
		1957	1958		Aug. 30	Nov. 18	Mar. 12	Mean	Sept. 24
Control	–	–	–	78	97·4	94·7	90·9	94·6	98·5
Dieldrin on seed* + 1 spraying	8	Sept. 2	Sept. 9	66	99·6	99·8	99·5	99·6	97·6
	12	Sept. 2	Sept. 9						
Dieldrin on seed* + 1 dusting	8	Sept. 2	Sept. 9	69	99·6	99·5	100·0	99·8	98·9
	12	Sept. 2	Sept. 9						
Dieldrin 2 sprayings	8	July 5	July 17	70	98·8	99·9	99·9	99·7	98·0
	8	Sept. 2	Sept. 9						
	8	July 5	July 17						
	12	Sept. 2	Sept. 9						
Dieldrin 2 dustings	8	July 5	July 17	74	98·1	99·8	99·8	99·4	98·2
	8	Sept. 2	Sept. 9						
	8	July 5	July 17						
	12	Sept. 2	Sept. 9						
Chlordane 2 sprayings	8	July 5	July 17	86	99·9	96·5	99·3	99·0	98·1
	8	Sept. 2	Sept. 9						
	8	July 5	July 17						
	12	Sept. 2	Sept. 9						
Endrin 2 sprayings	8	July 5	July 17	67	98·7	99·6	99·7	99·4	99·2
	8	Sept. 2	Sept. 9						
	8	July 5	July 17						
	12	Sept. 2	Sept. 9						
Means, excluding control					99·3	99·5	99·8	–	–

* Seed treatment 1 oz per lb 75 per cent Dieldrin on April 29 in 1957, May 2 in 1958.

The difference between the treated and untreated plots in 1956 was greater at the second and third dates, than at the first date of lifting. There was, at the two later dates, a significant improvement in the effectiveness of the high rate compared with the low rate of dieldrin, but no other meaningful comparison between the treatments was affected by the date of lifting. This was particularly evident by increasing the rate of dieldrin for the second spraying from 3 oz to 9 oz per acre when an increase in the percentage of clean carrots in the December lifting occurred (79·7), as compared with the September figure of 63·6 (Table 1). It was not so apparent in the case of 6 oz increased to 12 oz per acre, but an increase did occur. Both dieldrin and BHC seed dressings gave comparable control in 1956, and although the dieldrin seed dressing treatment was followed by chlordane (due to the material arriving too late for first generation application) effective control, comparable with any of the other spray treatments, was obtained. There appeared to be no advantage in applying 24 oz chlordane per acre as against 16 oz in 1956 (Table 1), and although in 1957 differences were small, chlordane at 8 oz per acre gave effective control (Table 2). Similar results were also obtained

in 1957 using endrin at 8 oz per acre. In 1957 there was also no significant difference between dieldrin applied as a spray or as a dust, which agrees with the findings of Wright (1959).

Although no clear differences were apparent between insecticide treatments in 1957, they all produced a significant increase in the percentage of clean carrots. Again, the later the date of lifting the greater was the effect on the percentage of clean carrots for all the treatments. In all the treated sub-plots (Tables 1 and 2) the degree of control is substantially maintained, whereas in the untreated sub-plots the injury increased rapidly, particularly in 1956 (Table 1). Although there was no overall difference between insecticides, chlordane tended to be slightly more effective than endrin at the earliest date of lifting and less effective at the later dates, suggesting that chlordane is not very persistent as a soil insecticide for controlling carrot fly by surface application.

In considering the whole series the effect of the first generation in 1956 caused approximately 20 per cent injury in the controls, which by September and December, due of course to second generation injury, had increased to approximately 50 per cent. Although in 1957 the traps (Fig. 1) indicated a concentration of first generation adults, only 2½ per cent damage occurred in the controls in August (Table 2). This small attack may be due to the fact that the carrots had not germinated until mid-late May, the period of adult activity, and after this period a general reduction in fly population and damage occurred. By March, 1958, the damage had increased to only 9 per cent within the 1957-58 trial, and by September, 1958, only 1½ per cent damage was observed in the 1958 experiment.

The original purpose of these trials in controlling carrot fly in crops left *in situ* all winter was thwarted to some extent, firstly by rabbit injury in the only year when moderate differences occurred between treatments and control, and secondly, by a natural and/or artificial reduction in the local population of carrot fly. However, the treatments all signified substantial control sufficient to offset any serious deterioration of crop quality due to fly injury.

We thank Mr. J. S. Panton for experimental facilities within the Horticultural Unit at Craibstone.

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WASTAGE OF APPLES IN RELATION TO THE WOOD USED FOR STORAGE BOXES

by J. COLHOUN,* G. MCELROY *and* P. J. WARD

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DURING 1958 some apple growers in Northern Ireland complained that severe wastage of Bramley's Seedling apples was apparently associated with the use of a certain type or types of wood in the construction of boxes used for unwrapped fruit in refrigerated gas stores. It was said that such damage had also occurred in previous years.

In the autumn of 1958 an experiment was started to ascertain whether a number of types of wood frequently used for apple boxes exercised any influence on the wastage of fruit stored in them. Through the co-operation of the Forestry Division of the Ministry of Agriculture, standard apple boxes of unseasoned beech oak, Douglas Fir, Lawson's Cypress, Norway Spruce, Scots Pine and Sitka Spruce were constructed. On October 23, 1958, each box was filled with 50 lb of unwrapped Bramley's Seedling apples; two boxes of each type of wood were placed in barn store and two in refrigerated gas store. The fruit in barn and gas store examined on January 21 and March 25, 1959, respectively, showed no indication of any unusual type of wastage.

During April, 1959, extremely severe wastage of Bramley's Seedling apples was observed in two refrigerated gas stores in County Armagh. In one store the damage in excess of normal wastage was estimated by the grower as exceeding £1,000. Inspection of the fruit *in situ* in these stores showed that the damage was largely associated with the use for the boxes of the wood of *Thuja plicata* Lamb. (Western Red Cedar). Samples of the wood were examined and identified by Mr. E .W. J. Phillips of the Forest Products Research Laboratory, Princes Risborough. In both stores many boxes contained one or more pieces of this wood and some of the boxes were made entirely of it. Apples in contact with this wood were often completely rotten, and fruit in the centre of the boxes, although not in contact with the wood, showed considerable wastage. There appeared to be a gradient in the extent of the damage from those apples in contact with the wood to those farthest away from it. When a box having the bottom made of wood of *T. plicata* rested on another not containing any wood of this type, it was found that the top layer of apples in the lower box was seriously affected, although the apples were not actually in contact with the *Thuja* wood. Isolations made from the diseased apples showed *Penicillium expansum* Thom to be the predominant organism present, although a number of other apple-rotting fungi were also isolated.

On September 22, 1959, Bramley's Seedling apples were placed in boxes made from freshly cut wood of *T. plicata*, and also of *Sequoia sempervirens* (Lamb.) Endl. (Redwood). Other boxes were made of partly seasoned wood of each of these two species, and also of fresh wood of *Picea sitchensis* (Bong.) Carr. (Sitka Spruce). Boxes made of wood of *T. plicata* in 1958 were also included in the experiment. Two boxes of each kind were filled with apples and placed in barn store, and two in refrigerated gas store. The apples were unwrapped and no lining papers were used. On December 1 the fruit in barn store was first observed to be showing peculiar discolorations on the skin. These markings were confined to apples in contact, or almost in contact, with green wood of *T. plicata*.

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Final observations on the fruit in barn store were made on December 21, 1959, and on the fruit in the gas store on March 31, 1960. The percentages of the apples in each box showing damage not attributable by eye inspection to normal fungal rotting were as shown in the Table.

Percentages of Apples showing Damage not attributable to Normal Fungal Rotting

Wood used for boxes	Barn Store				Refrigerated gas store	
	All apples		Apples in bottom layer only		All apples	
	Box 1	Box 2	Box 1	Box 2	Box 1	Box 2
Thuja plicata						
fresh	18·5	36·5	29·6	37·5	8·7	14·6
partly seasoned	4·3	5·5	4·4	6·3	2·1	0·8
year-old boxes	0	0	0	0	0	0
Sequoia sempervirens						
fresh	0	0	–	–	2·2	1·2
partly seasoned	0	0	–	–	0	1·8
Picea sitchensis						
fresh	0	0	–	–	0	0

In both the barn store and the gas store most of the damage was in the boxes made of freshly cut wood of *Thuja plicata*, but there was also some damage in the boxes made of partly seasoned wood of this species. In the barn store, where apples near the tops of the boxes had been disturbed by examination at intervals, those in the undisturbed bottom layers showed rather more damage than the rest. In the gas store each of the experimental boxes was surrounded by those that the grower was using commercially—in none of which was any damage observed. Possibly owing to better air circulation the damage in the boxes made of the wood of *T. plicata* was not so severe in the gas store as in the barn store. A little damage occurred in the gas store in boxes made of Redwood *(Sequoia sempervirens);* but there was no damage in those of Sitka Spruce *(Picea sitchensis)* or in the year-old boxes of *Thuja plicata*.

The damaged apples from barn or gas stores showed similar symptoms (Plate II, 1), irrespective of whether they were from boxes made of wood of *T. plicata* or *S. sempervirens*, although with the latter the damage was slight. On the surface of the affected apples there were slightly sunken areas, varying in size from 0·5 × 0·5 cm to 5·7 × 7·5 cm. The sunken areas were firm and mid-brown in colour. The damaged area often included the portion of the apple in contact with the wood, but it frequently extended beyond the area of contact. In some apples the portions touching the wood were undamaged but adjacent areas showed the typical damage. When the discoloured area measured less than 2 cm across it appeared to have one or two lenticels in the centre. Some lenticels lying between discoloured areas showed distinct brown halos but other lenticels in the same region were undamaged. The shape of the discoloured patches, whether large or small, was irregular, with the damaged cells extending to a depth varying from 0·1 cm in the smallest lesions to 1·0 cm in the largest. When only small areas were involved the affected internal tissue was of a dryish consistency but it was much softer in the larger lesions.

Isolations were made from 24 lesions on apples from boxes made of wood of *T. plicata* held in barn store; the size of the lesions varying from the smallest to the largest observed. *Penicillium expansum* was isolated from 11 of the lesions, other fungi from 7 of them, and no organism was found in the rest. The sizes of the damaged areas from which no organism was isolated varied from very small to very large.

From the observations made it appears likely that the damage reported may be due to a volatile chemical contained in green wood of *Thuja plicata* and perhaps also to some extent in that of *Sequoia sempervirens*. It is clear that unseasoned wood of *Thuja plicata* should not be used in the construction of apple boxes. It is difficult to distinguish this wood by its appearance as the colour may vary according to whether it is heart wood or sap wood. Fortunately, it is easily recognized by means of the characteristic penetrating smell, which is very pronounced when freshly cut unseasoned wood is examined.

SUMMARY

In 1959-60 a form of damage found to be occurring commercially in Bramley's Seedling apples in store in Northern Ireland was traced to the use of Western Red Cedar, *Thuja plicata*, in the storage boxes. In experimental boxes constructed of this wood and placed in both barn and refrigerated gas stores, Bramley's Seedling apples developed discoloured and slightly shrunken areas after normal periods of storage. The effect was most severe when unseasoned wood was used; it was not observed in year-old boxes. A slight but similar effect was noted in boxes made of Redwood, *Sequoia sempervirens*, in gas store. There was no such effect in boxes made of Sitka Spruce, *Picea sitchensis*.

We thank Mr. R. McIlwaine for the photograph.

FACTORS AFFECTING THE PHYTOTOXICITY OF METHAM-SODIUM TO TOMATOES

by D. HUNNAM *and* P. WADDINGTON

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DURING the spring of 1959, when formulations of metham-sodium had been on the United Kingdom market for only three or four months, many cases of blindness and malformation of tomato seedlings in the propagating stage were reported. The damage was soon found to be attributable to fumes from metham-sodium which had been applied in adjacent houses for soil sterlilization. Later in the same season similar symptoms were observed in plants soon after, and in some cases a considerable time after, setting out in the growing houses. The general pattern of the damage strongly suggested that the concentration of toxic vapours from the treated growing houses affecting the seedlings in the propagating houses must be very low.

Following these observations in practice, greenhouse experiments were devised to ascertain the actual concentration of the toxic gases required to cause damage. Tomato plants, 5 to 6 in. high in pots, were enclosed

in large inflated polythene bags (3 ft high by 2 ft in diameter) with either a measured amount of methyl isothiocyanate, MeNCS (the major breakdown product of metham-sodium) or with a quantity of metham-sodium in moist soil calculated to give the same MeCNS concentration. The bags were opened, collapsed and replenished at 24 hour intervals to maintain a relatively constant level of concentration for various periods.

The conclusions from these tests were that the inclusions of methyl isothiocyanate and equivalent amounts of metham-sodium had the same effect; that the phytotoxicity was entirely due to fumes of MeNCS; and that as little as 0·05 p.p.m. of this substance in the air about the tomato plants for a period of two days was sufficient to cause serious stunting.

TRIALS IN 1959–60

In the 1959-60 season, the method of testing soil samples by enclosing them with tomato plants in large polythene bags was applied to soils after experimental treatment in 18 commercial houses in the Lea Valley area to ascertain the effect of a number of factors, including method and date of application, soil temperature and soil type, on the potential phytotoxicity of metham-sodium applications in practice.

In these trials metham-sodium (32·7 per cent a.i.) was applied throughout at the rate of 1 pint per 50 sq. ft of soil surface; and this application was made in each of four ways:

I In 1½ gal water, rotovated in, followed by a light water seal, and then by further rotovation to facilitate escape of fumes.

II In 1½ gal water, rotovated in, without water seal, followed by digging.

III In 1½ gal water, rotovated in, with a light water seal, followed by digging.

IV Flooding, in 25 gal water, followed by rotovation.

With each treatment two cultivations were given, at 14 and 21 days after the application, for the removal of fumes.

Soil samples from the treated areas, at a depth of 3 to 6 in. were taken 2½, 4, 6, 8, and 10 weeks after the applications. The soil samples were collected in polythene bags and brought in to an experimental greenhouse at Wheathampstead where they were tested. The soil sample was spread out in the bottom of the large polythene bag, two test tomato plants in pots were put in, the bag was inflated and then left sealed for seven days. The temperature of the greenhouse was maintained at 60°F throughout.

The test plants, on removal from the bags, were graded for phytotoxicity effects according to the following scale:

0 No adverse symptoms
1 Slight curling of a few leaves
2 Curling of the majority of the leaves
3 Curling and etiolation of leaves
4 Severe curling and leaf drop
5 Plants dead.

Soil treatments by each of the four methods, I, II, III and IV, were carried out in October in 14 houses; in November in 18 houses; and in December in 6 houses. The mean grading for phytotoxic effect of soil samples taken 2½, 4, 6 and 8 weeks after each of the October and November treatments are given in Table 1.

It was expected that the use of large amounts of water in the flooding treatment (IV) would tend to check escape of fumes from the soil, but, as the figures in Table 1 clearly show, there were no differences in effect between the four methods of application.

TABLE 1

Mean Phytotoxicity Grading of Soils after Treatment with Metham-Sodium by Four Methods in October and November, 1959

Weeks after application	October application (*Means of 14 Trials*)					November application (*Means of 18 Trials*)				
	I	II	III	IV	Control	I	II	III	IV	Control
2½	3·8	2·9	3·0	3·0	0·1	4·3	3·7	3·8	3·5	0·2
4	2·4	2·5	2·2	2·0	0·1	2·3	2·4	1·7	1·8	0·1
6	1·9	2·0	1·8	1·6	0·3	0·8	1·1	0·9	0·6	0·1
8	0·9	1·1	0·8	0·8	0·0	0·4	0·5	0·4	0·2	0·1

It was found that the test plants showed less response to the toxic vapour as the season advanced; when the growth of the plants had almost ceased, in late December and January, the amount of damage was almost nil. For this reason the results of the tests with October applications are more reliable than those with application in November, and the results of the applications in December and early January are omitted.

It is probable that soil at a low temperature is more retentive of MeNCS than that at a higher temperature. The anticipated effect of lower soil temperatures in November than in October is not brought out by the mean results of all the trials in Table 1, where the lower mean phytotoxicity gradings for the soil samples taken 6 and 8 weeks after November application are almost certainly due rather to low response of the test plants in the winter than to lower output of fumes from the soil. In houses No. 5 and No. 6 (for other particulars see Table 2) there was some evidence of higher phytotoxicity with lower soil temperature in November, thus:

House	Date of Application	Soil Temperature °F	Grade for Phytotoxicity at weeks after Treatment: 2½	4	6	8
No. 5	Oct. 15	63	2	2	3	2
	Nov. 5	54	5	5	3	2
No. 6	Oct. 16	60	2	2	2	1
	Nov. 6	50	4	1	1	1

The information obtained on the effect of soil type on phytotoxicity is shown in Table 2. In this Table the 14 commercial houses in which October applications were tested are arranged in order of the mean gradings for phytotoxic effect of all four methods of application in that month. The organic content, soil conductivity and clay content of each soil was determined before treatment.

There is an indication from Table 2 that the soils with a high clay content (23 per cent or more) were more retentive of metham-sodium vapours than those in which the clay content was low (less than 19 per cent). House No. 16 had soil with a low clay content and comes higher in the Table than would be expected; it had however quite the highest pC. House No. 4 comes low in the Table but had the lowest organic content.

TABLE 2

Mean Phytotoxicity Gradings for October Treatments with Metham-Sodium in 14 Commercial Houses, in Relation to Soil Factors

House No.	Grade for Phytotoxicity at weeks after treatment:				Organic Content	Soil Conductivity expressed as:		Clay Content
	2½	4	6	8		CF	pC	*per cent*
2	5	5	5	0	10·3	16·5	2·8	27·2
7	5	4	3	1	6·7	9·5	3·0	23·0
3	4	4	2	2	9·7	14·0	2·9	35·0
15	5	4	3	0	4·6	10·8	3·0	29·2
13	4	3	3	–	7·9	10·5	3·0	19·8
9	5	3	2	0	7·2	17·5	2·8	19·7
5	2	2	3	2	4·0	12·6	2·9	22·0
16	4	3	1	1	7·3	5·2	3·3	17·3
6	2	2	2	1	8·0	11·5	2·8	19·2
10	3	3	1	0	5·9	11·5	2·9	14·7
8	3	1	1	0	8·8	19·3	2·7	18·7
12	2	1	1	0	5·7	8·2	3·1	15·0
4	3	0	–	–	3·1	7·7	3·1	21·2
1	0	0	–	–	7·9	8·2	3·1	18·0

In all the 14 houses referred to in Table 2 observations were made on the response of plants set out in the normal commercial way after the soil sampling for these trials had been completed. In all but two of the houses no phytotoxicity was noted; the two exceptions were houses No. 2 and No. 3, for which the phytotoxicity gradings were among the highest on test (Table 2), and in which there was a slight phytotoxic response in the following crop. These observations in the houses supported the validity of the polythene bag testing technique, which has indicated that although most soils can safely be treated with metham-sodium (provided the soil is properly opened after treatment and left well ventilated for 10 weeks before plants are brought in) there are some soils likely to be abnormally retentive and thus always suspect.

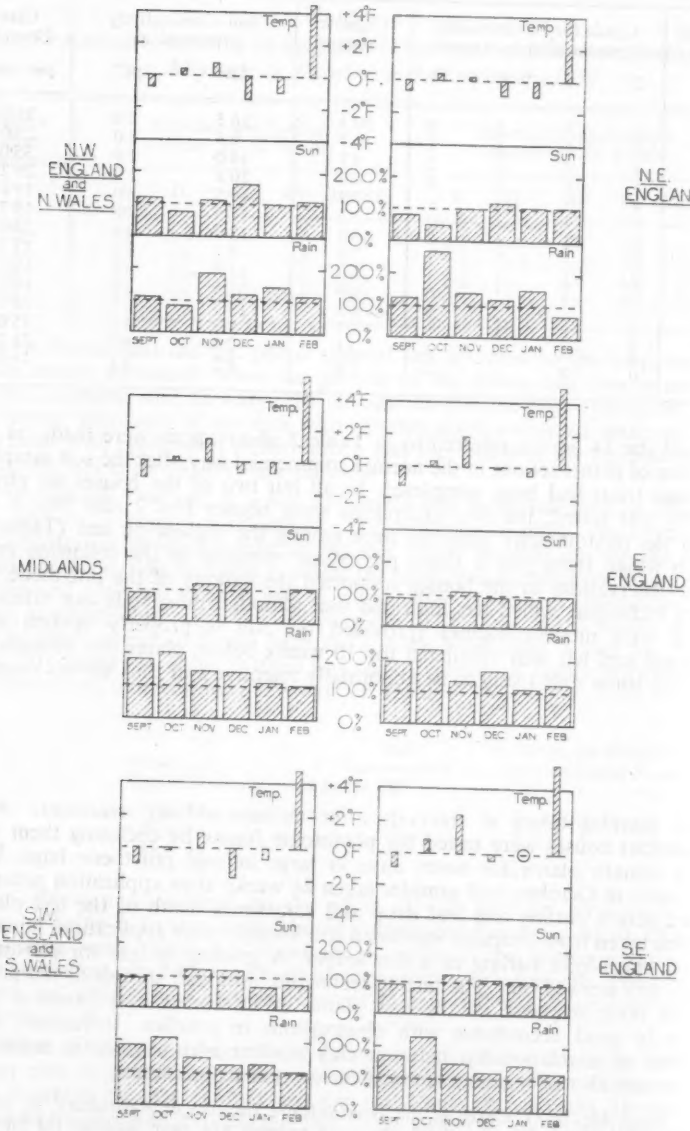
SUMMARY

Soil samples taken at intervals after metham-sodium treatments in 18 commercial houses were tested for phytotoxic fumes by enclosing them with young tomato plants for seven days in large inflated polythene bags. With treatments in October, soil samples taken 2½ weeks after application generally caused severe curling and leaf drop and sometimes death of the test plants; samples taken from properly ventilated soil 8 weeks after application, however, caused only slight curling of a few leaves. A grading system for phytotoxic effects was worked out. The testing technique, although subject to limitations due to poor response of the test plants in December and January, gave results in good accordance with observations in practice. Indications were obtained of a relationship between clay content and phytotoxic retentivity in soil, and also of higher retentivity at low soil temperatures.

We thank Mr. E. G. Coker of the Hertfordshire Institute of Agriculture, St. Albans for the soil analyses. We also thank the many growers who gave facilities for the trials in their houses, and the members of the Murphy staff who made the treatments and took the soil samples.

SEPTEMBER–FEBRUARY WEATHER 1960–61

Variations from Average



THE WEATHER OF ENGLAND AND WALES*

AUTUMN AND WINTER 1960-61

EXCEPTING in the north-west of the country, the rainy weather of late summer continued throughout the autumn. There was a short warm sunny spell about the 10th of September but most of the time it was cool and changeable with air and ground frosts towards the end of the month. October was exceptionally wet and dull with extensive flooding in many parts of the country from Lincolnshire to Devon. The July to October rainfall in 1960 was the highest ever recorded since records began in 1727. In October alone about 28 thousand million tons of water fell on England and Wales. November followed with similar but not so extreme weather; it was mild with reasonable amounts of sunshine.

The winter started with more wet and stormy weather in early December but the general weather became less violent later, and drier periods with frost and fog followed. January was a mixed month with alternating spells of mild stormy westerly weather and dry cold easterly winds. Severe winter conditions, however, never became firmly established and February was outstandingly mild with mean temperatures 4·5°F above average. Rainfall was heavy at the beginning and end of the month, but the middle fortnight was dry almost everywhere; it was in fact the longest dry spell in south-east England since September, 1959.

The weather for each of the six months September to February, inclusive, is represented graphically on page 122. Figures for six districts of England and Wales are shown in terms of the deviation from average of air temperature, sunshine and rainfall. Conspicuous features are the rains of October and the warmth of February.

NEW OR UNCOMMON PLANT DISEASES AND PESTS

Fungi on Highbush Blueberries *(Vaccinium corymbosum).* Dieback of young shoots and cankers on twigs and on the main stem were noted on young bushes of the variety Grover in a consignment of blueberries imported from Holland in 1954 and planted at a centre in Kincardineshire. At the North of Scotland College of Agriculture, Aberdeen, we found pycnidia of two fungi present on most of the lesions. One corresponded with *Fusicoccum putrefaciens* Shear, the other was identified as the *Phomopsis* stage of *Diaporthe vaccinii* Shear. By 1956, all the diseased bushes were dead. The other varieties in the consignment, Concord, Rubel and Rancocas, were not affected.

In June, 1960, these two fungi were found on dying plants of the varieties Berkeley, Blueray and Earliblue, imported into Britain from New Jersey in autumn 1959 and planted in the trial grounds at Craibstone in the following

* These notes and the diagrams on page 122 are provided by the Agricultural Unit of the Meteorological Office and are published by permission of the Director-General.

March. Fructifications having the appearance of empty apothecia were present on some plants and *Pestalotia* sp. was abundant on dead bark. In September, 1960, pycnidia of *Fusicoccum* and *Diaporthe vaccinii* were found on dying shoots and cankers on blueberries imported from New Jersey in 1956 and planted then in Kincardineshire alongside the surviving bushes of the first importation. Apothecia which developed on these shoots in February, 1961 (Plate II, 2) were identified by Mr. D. Henderson and Dr. R. W. G. Dennis as *Crumenula urceolus* (Fries) de Notaris.

Fusicoccum putrefaciens and *Godronia cassandrae* Peck have been reported in recent years as the cause of a fairly serious disease of blueberries in Nova Scotia (Creelman, D. W., *Plant Dis. Reptr.*, 1958, **42,** 843-5); British Columbia (McKeen, W. E., *Phytopathology*, 1958, **48,** 277-80); Massachusetts (Zuckerman, B. M., *Plant Dis. Reptr.*, 1959, **43,** 803); and Finland (Hardh, J. E., *Maataloust. Aikakausk.*, 1959, **31,** 131-40). Creelman refers to differences between the fungus on blueberry and *Godronia cassandrae* on *Chamaedaphne (Cassandra) calyculata*. He mentions Dr. Groves' opinion that they are distinct, and that the *Vaccinium* fungus should be referred to a genus other than *Godronia*. According to Seaver *(Mycologia*, 1945, **37,** 333-59) *Godronia cassandrae* described by Peck from *Cassandra calyculata* is identical with *Godronia urceolus* (Alb. and Schw.) Karst, a synonym for *Crumenula urceolus*.

Diaporthe vaccinii, described on blueberry by Wilcox *(Phytopathology* 1939, **29,** 136-42; 1940, **30,** 441-3), is of minor importance in the United States.

H. J. WILCOX and MARGARET A. FALCONER

Leaf Spot of Chrysanthemum caused by *Septoria obesa*. Leaf spots observed on a number of American spray chrysanthemum varieties growing in a cold glasshouse in West Sussex were found to be associated with a pycnidial fungus differing in both microscopic and macroscopic symptoms from blotch *(Septoria chrysanthemella* Sacc.). The spots were brown in colour, round to ovate in shape but occasionally angular when bordered by the veins, and surrounded by a conspicuous chlorotic halo when young. Spots varied from 1/8 to 1/2 in. diameter but frequently coalesced to form extensive necrotic areas on both old and young leaves. Pycnidia were abundant and from them oozed light-coloured spore tendrils. The spores were smooth, hyaline, thickened at the base but tapering towards the apex giving a characteristic whip-like shape. The number of septa varied from 5 to 13 and the size of the spores from 65-112 $\times$ 2·5-3·5μ. Septation was best observed when spores were mounted in iodine or lactophenol. The spore characters agreed closely with those described for *Septoria obesa* Syd. (see Schneider, R., *Phytopath. Z.* 1959, **34,** 269-84). Leaf spots due to *S. chrysanthemella* are generally more angular and much darker than those due to *S. obesa;* spore tendrils are rarely seen and the spores, measuring 23-72 $\times$ 1-3μ, are uniform in width, and have 3 to 6 septa. While leaf spot caused by *S. obesa* Syd. is known to occur in the U.S.A., Europe and the Far East, this record appears to be the first for Great Britain.

H. J. WILCOX and MARGARET A. FALCONER

Downy Mildew of Perpetual Strawberry. In autumn 1958, a downy mildew caused substantial loss of fruit in a half-acre crop of Baron Solemacher strawberries near Tonbridge, Kent. Fruits remained wholly or partially undeveloped, affected areas turned necrotic and supported under moist conditions a whitish growth of *Peronospora* conidiophores. These also developed profusely on sepals

and occasionally on necrotic leaf spots. No oospores were found, but the ellipsoid conidia, 16-18 × 20-22μ, agreed closely with those of *P. fragariae* Roze and Cornu, first recorded in 1876 causing damage to cultivated strawberries around Paris. There is a British collection with similar measurements on wild strawberry in Herb. I.M.I.,Kew. *P. fragariae* has been reduced to synonomy with *P. potentillae* de Bary, although the fungus attacking *Potentilla* seems to have slightly larger conidia and to differ in oospore structure *(fide* Miss Grace M. Waterhouse). No other strawberry varieties were grown on the farm, and the origin of infection in Baron Solemacher is obscure. Its growth habit suggested that this variety might not withstand burning over after cropping as a control measure, so the foliage and peduncles were cut off and gathered up to be burned elsewhere. Bordeaux mixture (4 : 5 : 40) was sprayed over the dormant plants the following February and again in March, followed by an application of captan to the spring growth. In spite of wet autumns in 1959 and 1960, there has so far been no apparent recurrence of the disease; but the 1959 dry summer may have been the main factor.

W. T. DALE

Frit Fly in Maize. In 1960, an attack of frit fly, *Oscinella frit* L., developed on a 11½-acre field of maize being grown for silage on the farm at Harper Adams Agricultural College. The seed was sown on May 2 and 3 in a heavily fertilized seedbed and emergence began on May 14. Early growth was slow owing to dry conditions and was checked during the first fortnight of June. From June 14 onwards the crop looked better and soon became very vigorous. The field had been drilled with more than one variety, but the frit fly attack was fairly uniform over the field. On the medium-early variety Wisconsin 270 attack by first-generation frit became apparent on June 2 when the crop was 3-4 in. high, and in the 3-4 leaf stage. The crop then looked yellow and sick; a number of plants had puckered and twisted leaves, often joined to one another, and here and there the central shoot was wilting and yellow, with the older leaves purplish-red in colour. Such plants were distinctly stunted, though at this stage it was difficult to find frit larvae by shoot dissection.

By June 17 two types of damage could be seen: a curling and twisting of one or more of the leaves, accompanied by deformation and puckering with slight chlorosis (Plate I, 1, *right)*; or a marked stunting of the whole plant, with chlorosis of the leaves and advanced necrosis of the central shoot (Plate I, 1, *left).* At this date healthy plants were in the 7-9 leaf stage, and 6-8 in. high; moderately attacked plants were 4-5 in. high; and severely damaged plants were 3-4 in. Frit-fly larvae could be found quite easily by dissection, most being third instar, while second instar larvae and an occasional pupa were usually found in the area of the lower nodes of the severely stunted plants.

The stronger plants had formed 1-2 tillers by June 21, and from that time onwards it was common to find healthy main shoots with severely attacked tillers the lower nodes of which were beginning to rot. After the second week in June the crop began to recover, and was very vigorous by the end of the month, when the average height of the healthy plants was 20 in. No control measures were applied. The angular percentage frit attack on June 23 was estimated to be 21·0 ± 4·8 (= 13 per cent detransformed) by visual assessment along a diagonal traverse.

I am indebted to Dr. I. W. B. Nye, Commonwealth Institute of Entomology, for confirming the identity of the frit fly larvae, and to Mr. R. Harris for the photograph.

J. R. PARRY-WILLIAMS

Damping-off of Antirrhinum Seedlings by *Phyllosticta antirrhini*. The disease of *Antirrhinum majus* caused by *Phyllosticta antirrhini* is known as stem rot and is not normally associated with damping-off of seedlings. In the U.S.A., Guba and Anderson *(Phytopathology,* 1919, **9,**, 315-25) have observed and described a damping-off phase. Previous work in this country (Buddin, W. and Wakefield, E. M., *Gdnrs'. Chron.*, 1924, **76,** 150-2) showed that the fungus was mainly a wound parasite and, where seedling infection was observed, it was attributed either to contamination of the seed sample with pieces of infected seed capsule, or to faulty hygiene. It is therefore of interest to record an experience in the West Midlands in 1960. In the spring a dozen reports were received from nurserymen of severe and extensive damping-off of antirrhinum seedlings, or of leaf-spotting, malformation and distortion of the older seedlings after pricking out. On investigation of all these cases pycnidia of *P. antirrhini* were found on the affected tissues. Seed infection appeared probable as the standard of hygiene on the nurseries was good, and there was no likelihood of infection from diseased material remaining from previous seasons. Small amounts of the seed left over at some of the nurseries were bulked and samples germinated in four petri-dish damp chambers at room temperature. There was 90 to 95 per cent germination, but in each of the dishes a number of seedlings collapsed with a brown discoloration of the hypocotyl and cotyledons. Abundant pycnidia of *P. antirrhini* were found associated with the lesions, but these pycnidia were difficult to detect on the dark and sculptured seed coats.

W. R. ROSSER

***Brevipalpus obovatus* Donnadieu in Staffordshire.** This small red mite, which has previously been recorded in this country only from Kew, was found to be damaging a number of varieties of ivy *(Hedera spp.)* in a glasshouse in south Staffordshire. The mites were first seen on June 30, 1960. All stages were bright red, and were found on both surfaces of young leaves and mainly on the undersides of older leaves; on the older leaves they tended to congregate around the leaf margins. On plants with variegated margins to the leaves (e.g., *H. glauca*) there was severe marginal necrosis leading to ' cupping ' of the leaves. On varieties with entirely green leaves (e.g. *H. helix* ' Chicago ') necrosis was generally confined to the tips of the leaf lobes. The distinction, however, may be one of leaf shape as the green varieties all had deeply lobed leaves whereas the variegated forms had leaves which were comparatively smooth in outline. In both cases there was slight reduction in leaf size. Mites of this species were found associated with brown areas on the leaves of *Cissus antarctica* and *Rhoicissus rhomboidea;* mites and eggs were also found on *Fatshedera* sp., *Peperomia* sp. and *Elettaria cardamomum.*

The species was recorded by Dosse *(Pflsch. Ber.*, 1957, *18*, 13-17) from glasshouses in Austria (on *Hedera* and *Azalea),* Germany (on *Campanula, Aralia* and *Cissus)* and Holland (on *Gardenia).*

Spraying with malathion, parathion and fluoracetamide was tried without marked success. Chlorobenzilate (0·02 per cent) appears to have given satisfactory control. I thank Mr. D. Macfarlane, of the Commonwealth Institute of Entomology, for confirming the identity of the mite.

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